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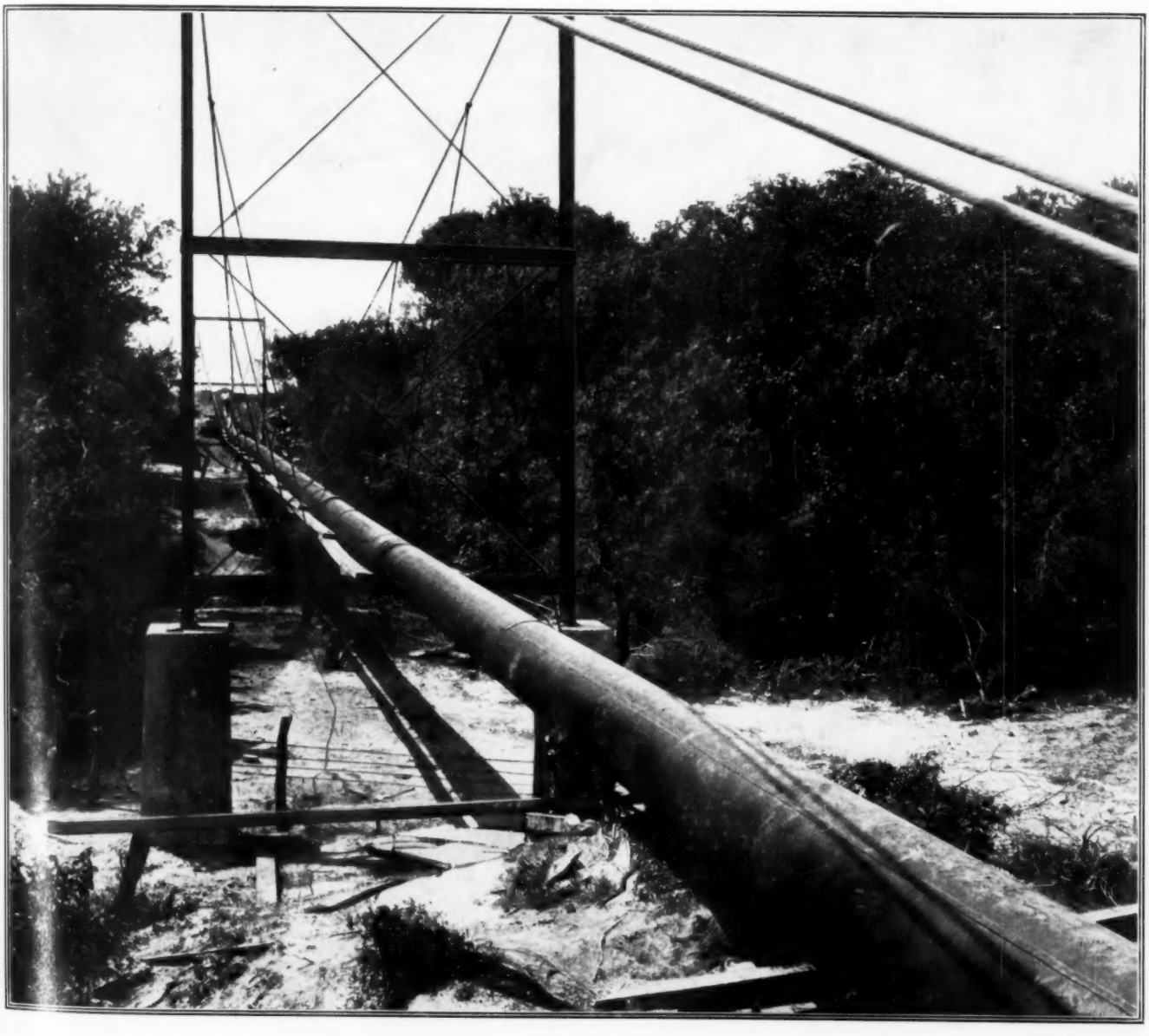
MECHANICAL ENGINEERING



February 1932

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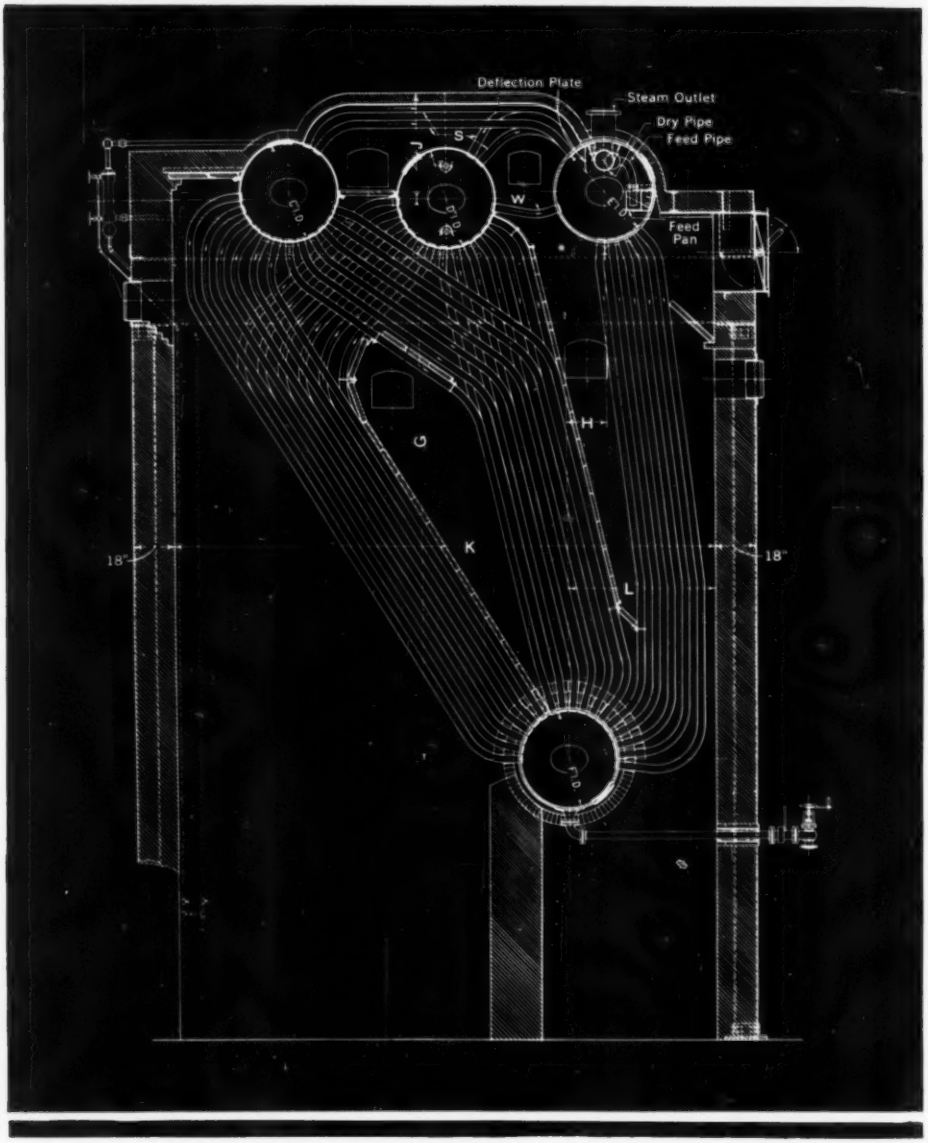

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MECHANICAL ENGINEERING

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WHAT IT'S ALL ABOUT

UNDOUBTEDLY the times justify the emphasis on non-technical aspects of engineering, such as economics and psychology, which the January issue of MECHANICAL ENGINEERING gave. But regardless of the fact that the entire world is thinking more broadly, and, we hope, more constructively, on its social and economic problems, we are convinced that the engineer has an especial obligation to himself and to civilization in clarifying his thinking on these subjects and translating it into well-coordinated action. As we have frequently pointed out, it is not so much technology that we have to worry about—although every one will admit that the production of a device that people will insist upon buying and using in large quantities would stimulate business at the present time—as it is the proper integration of the effects of technology into contemporary society. What we should concern ourselves with is a proper emphasis on values as contrasted with things, or on values as affected by things, and on purposes and trends in the development of civilization.

THE engineer is becoming a more important actor in the great human drama, and hence versatility and breadth of understanding and culture become more essential to him. In this connection S. M. Kintner, vice-president in charge of engineering of the Westinghouse Electric & Mfg. Co., has recently uttered the paradoxical statement that the engineer of the future must be both broader and narrower than his predecessor. He will study more cultural subjects and also devote more time to economics and psychology. Because of the conditions under which the future engineer will work he will be less content to limit himself to personal interest and less willing to let the rest of the world look after itself. He will be glad to assume his full duties as a citizen. Also, he will know more about engineering.

These statements, coming from an eminent engineer who is very close to many major engineering developments, are enlightening and encouraging. They are in accord with the editorial policy of MECHANICAL ENGINEERING, which is attempting to assist the broadening influences at work among its readers, at the same time having in mind the very important function of an engineering magazine to provide as much as possible of what is new and significant in engineering developments.

To engineers of all schools of thought—from those who desire broad, significant articles to whose who want the latest in technical developments—we commend this February issue.

PROFESSOR LARKIN, of Lehigh, with the philosophic detachment of a busy man on an extended holiday, has sent us from the mid-Pacific his impressions on seeing for the first time an engineering achievement that has been a symbol of professional idealism with him since early manhood. Such reaffirmation of long-cherished ideals and such a rebirth of enthusiasm for his profession as came to Professor Larkin as he sailed through the Panama Canal, offer convincing evidence of the powerful influence that the spirit of engineering accomplishment has over man. At the beginning of a journey around the world which is to bring him in contact with the great cultures of the past and present, Professor Larkin has written, "I know that beyond the possibility of any future doubt or fear, art, music, romance—all that signifies the spirituality of man—are within the province of the engineer."

THE Panama Canal is a spectacular symbol, dramatizing effectively man's conquest of his natural environment. The problems involved in it were varied: engineering, sanitation, politics, and economics, carefully studied and weighed, made the thing possible. It was not solely an engineering problem. It stands today as evidence that engineering projects involve numerous considerations with far-reaching effects. In the field of transportation, for example, it has affected the railroads. It is one of many engineering developments that have offered competition to our major transportation system.

DR. JULIUS H. PARMELEE, in an article published in MECHANICAL ENGINEERING for March, 1931, gave statistics covering the competition in our transportation facilities. Since that time the financial condition of the railroads has received much public attention, and recent developments promise an improvement of it in the near future. As this is being written, Congress is considering favorably a Reconstruction Finance Corporation which, among other things, will enable certain roads to meet bond and note maturities in which many classes of investing institutions are vitally interested. Provision for interest payments has already been made by the formation of the Railroad Credit Corporation, which will administer the freight-revenue pool worked out by the I.C.C. and the railroad executives. Railroad employees on certain systems are accepting cuts in wages that will be translated into reduced operating expenses. Furthermore there seems to be a disposition on the part of the I.C.C. and others to place competitors of the railroads under regulatory control. These factors, combined with a satisfactory solution of the consolidation problem, if such a solution is possible, are doing much to improve railroad credit, and with railroad credit on a sounder basis, many engineers will feel the effects in their own businesses.

PIPE lines come in for a share of consideration when railroad competition is discussed. In the September, 1931, issue of MECHANICAL ENGINEERING, H. R. Moorhouse presented some statistics on gas pipe lines. The leading article this month, on Pipe-Line Transportation, deals with oil as well as gas lines, and with

both engineering and economic phases of the subject. The author is Prof. J. H. Pound, of the Rice Institute, Houston, Texas, and the paper was one presented before Section M (Engineering) of the A.A.A.S., at its recent meeting in New Orleans.

SINCE we have already mentioned two papers previously published in MECHANICAL ENGINEERING that are significant because of developments in the day's news, we may recall the paper by Alford and Hannum on the kilomanhour which appeared in March, 1929. A committee of the American Engineering Council recently demonstrated that statistics on technological unemployment could be conveniently and intelligently reported in terms of this unit, and it is our understanding that the Bureau of Labor Statistics is to use the Alford-Hannum unit in compiling data on this important subject.

PORTRAIT OF AMBROSE SWASEY, PAST-PRESIDENT AND HONORARY MEMBER, A.S.M.E., RECENTLY UNVEILED BY THE ARTIST, PHILIP A. DE LASZLO, AT A LUNCHEON GIVEN IN HONOR OF MR. SWASEY ON HIS 85TH BIRTHDAY BY THE CLEVELAND CHAMBER OF COMMERCE. SEE PAGE 155.

FACTS are urgently needed to clarify our thinking on unemployment questions. Cause and effect seem to be following each other in confusing circles. Exports of machinery and technique have been followed by imports of competing raw materials and consumer goods produced by cheaper labor abroad. Economics in management and attempts at stabilization to swing domestic profits into line attack the labor item, forcing either fewer manhours per unit produced or reduced rates of pay. We are told in a report recently issued by the International Labor Office in which conditions in Detroit were compared with those in 14 European cities, that low wages mean low standards of living. Again the economic and social factors rub shoulders with engineering.

ATTACKING the problem of reduced production costs from another angle, C. H. McKnight, in this issue of MECHANICAL ENGINEERING, discusses material waste. His particular concern is about waste that is frequently considered to be unavoidable, and he gives specific examples to show how reductions have actually been accomplished by the General Electric Company, which he serves as supervisor of waste and spoilage.

BUT enough of this; we promised also something appealing to those who prefer more strictly technical papers. Besides sixteen pages of abstracts of engineering developments gleaned from the press of the entire world, provided in the Survey, four pages giving synopses of papers recently published in sections of the A.S.M.E. Transactions, and eight pages of selected Engineering Index items, we can "point with pride" to the group of reports presented at the December meeting of the A.S.M.E. Research Committee on the Thermal Properties of Steam. Here will be found what has been going on at M.I.T., as reported by Drs. Keyes and Smith, who are studying the p-v-T relationships, and an account of progress in steam research at the Bureau of Standards, in which Dr. Osborne describes the new calorimetric equipment for extending the heat-content measurements on saturated steam beyond the 800-lb limit that had been reached with the apparatus previously used. What has been transpiring in Europe is reported by Dr. Harvey N. Davis.

Two brief contributions of interest to those who design and lubricate bearings will also be found, one describing trends in the capillary lubrication of plain bearings, and the other reporting some experiences with lead oleate-oil lubricants that resulted in explosions.

From the preface by H. W. Gillett of the impressive "Symposium on the Effect of Temperature on the Properties of Metals," presented at a joint meeting of the A.S.T.M. and the A.S.M.E. in Chicago last June and now available in book form, an extensive abstract is included in this month's MECHANICAL ENGINEERING. Mr. Gillett was chairman of the Symposium Program Committee. He is the director of the Battelle Memorial Institute, Columbus, Ohio.

Next month—another "balanced ration."

PIPE-LINE TRANSPORTATION

Economic and Engineering Problems Resulting From the Rapid Extension of This Modern Utility Into New Fields

By J. H. POUND[1]

THE problems to be discussed here are of two kinds: the economic problems developed by the pipe-line industry, especially among its competitors, and the major engineering problems determining the cheapness of pipe-line transportation of liquids and gases. The solution of these problems will affect many people in this country.

The years 1929 to 1931 were years of great activity in pipe-line construction of all sorts. In that period the mileage of the crude-oil lines in the United States increased about 9 or 10 per cent, that of the gasoline pipe lines 500 to 600 per cent, and that of the natural-gas lines about 30 per cent. The mileage of the longer crude-oil lines has increased as shown by Fig. 1, and the annual increase in the quantities of natural gas transported in long pipe lines is shown by Fig. 2. This construction has resulted in an oil-pipe-line system in the United States of about 100,000 miles, and in a natural-gas network of about 50,000 miles, the latter being substantially as shown in Fig. 4.

The rapid expansion of these facilities brought new competitors into many existing fuel markets, and also threatened competition to the transportation agencies feeding these markets. This condition caused so much concern to the coal industry and to the railroads that during the past two years their worries have been freely described to the public. They may even be discussed seriously at the current session of Congress. Such publicity has drawn the attention of many people to some very interesting economic conflicts.

GROWING COMPETITION OF NATURAL GAS WITH COAL

The coal industry is of course subject to direct competition from pipe-line fuels, especially from gas. Although its loss of market to gas is small at present, competition threatens to increase as the pipe lines expand. To quote the most recent data released by the Bureau of Mines, in 1930 the total useful consumption of natural gas in this country was 1941 billion cubic feet, which in heating value is equivalent roughly to 75 million tons of good soft coal. But not all of this gas comes in serious competition with coal. The items listed in Table 1 under oil- or gas-field use, carbon black, and refinery fuel are of this type, and they account for about 69 per cent of the total consumption of natural gas. The remainder is an amount equivalent to perhaps 23 million tons of coal, of which possibly 20 million are really competitive with coal. This 20 million tons is only about 3 per cent of the annual coal production.

But although the coal market lost to natural gas seems small at present, rapid increases are occurring in the volume of natural gas competing with coal, in the total production of natural gas, and in the volume of gas in interstate transportation. The rate of increase in total production and in interstate movement is shown in Fig. 3. During the past ten years the increase in total gas production each year has averaged 10 per cent over the preceding year, though in 1930 the gain was only 1.3 per cent over 1929. The total transported between states increased 17 per cent between 1929 and 1930, and the large item of domestic consumption increased 18 per cent in 1929, and even 5 per cent in 1930.

TABLE 1 NATURAL-GAS CONSUMPTION IN 1930

(Data from U. S. Bureau of Mines)

	Billion cu ft	Per cent
Domestic consumption	376	20
Industrial consumption	1565	80
Total consumption	1941	100
Distribution of industrial gas:		
Used in oil or gas fields	723	46
Carbon black	266	17
Electric power plants	120	8
Oil refineries	98	6
Portland cement	41	3
Miscellaneous industrial	315	20
	1563	100

The future growth of these figures depends very largely on our ability to transport such gases cheaply. At present, the large consumption of natural gas occurs in places far from good coal and without the benefit of cheap freight rates—for example, in the southwestern states and in California; but if the pipe lines can be extended with profit to their owners, the items of domestic consumption, electric generation, and general industrial use can be expected to increase considerably, and at the expense of other fuels.

In many of these industrial services, natural gas is strongly favored against even less expensive fuels because of the ease of controlling combustion efficiency and furnace temperatures. Industries in which natural gas has found a good market include those manufacturing steel, glass, and cement, and also bakery and ceramic products. As a domestic fuel, the convenience and

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[1] Professor of Mechanical Engineering, The Rice Institute, Houston, Tex. Mem. A.S.M.E.

cleanliness of gas are strongly in its favor; however, in this field natural gas must compete with producer gas made from low-grade coals.

In the public-utility field a number of large steam-generating plants have already switched to gas fuel,

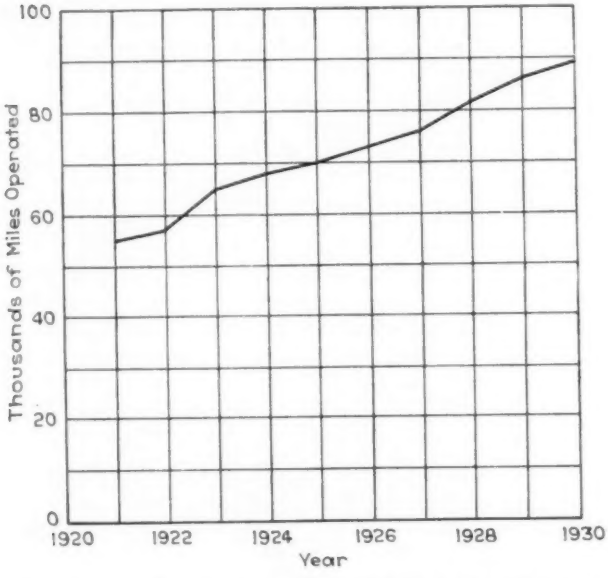


FIG. 1 MILEAGE OF INTERSTATE PETROLEUM PIPE LINES
(Data from reports of Interstate Commerce Commission.)

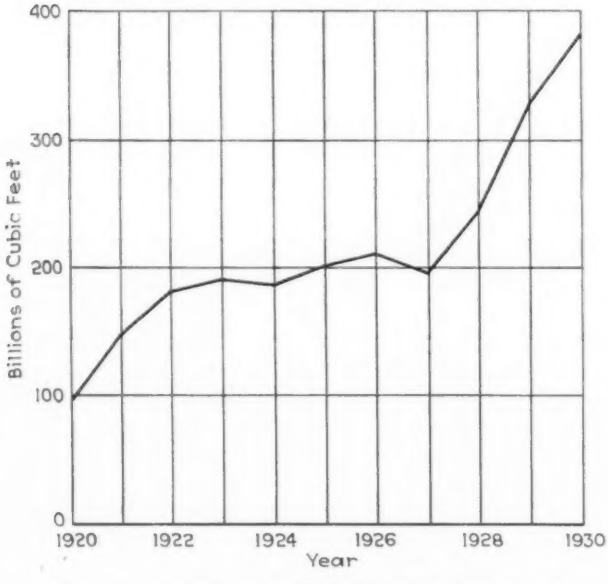


FIG. 2 INTERSTATE MOVEMENT OF NATURAL GAS
(Data from U. S. Department of Commerce.)

though in these cases the fuel abandoned has often been oil. (See Table 2.) Large stations using natural gas for this purpose are found in Houston, Dallas, Memphis, New Orleans, and Little Rock. An appreciable consumption is traceable to the many small isolated power generators, and the large sulphur mines of the Southwest are also good gas customers. Even the oil refineries

TABLE 2 FUELS USED IN PRODUCTION OF ELECTRIC POWER IN THE UNITED STATES, 1919-1928
(G. Egloff, World Power Conference, 1930)

Year	Coal	Oil	Natural gas
	Per cent		
1919	90.0	6.7	2.4
1920	90.0	7.4	2.6
1921	89.2	7.9	2.9
1922	88.9	8.0	3.1
1923	89.1	7.8	3.1
1924	86.3	8.9	4.8
1925	90.1	5.4	4.5
1926	90.2	4.8	5.6
1927	90.7	3.4	5.9
1928	89.2	3.6	7.2

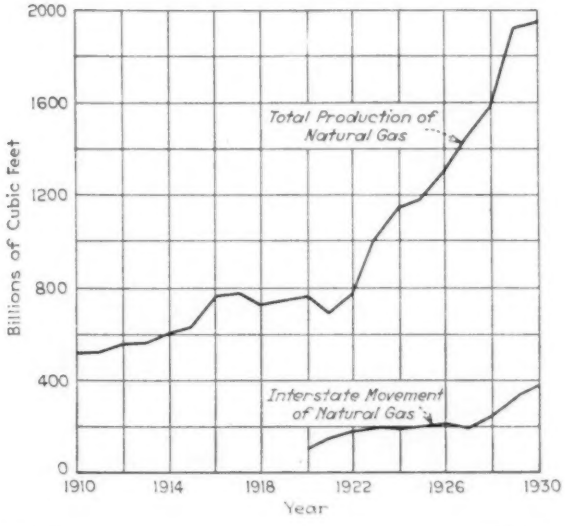


FIG. 3 TOTAL PRODUCTION AND INTERSTATE MOVEMENT OF NATURAL GAS
(Data from U. S. Department of Commerce.)

find inadequate their many by-product fuels, and in normal times they purchase large quantities of natural gas from the pipe lines.

It may be objected that natural gas can never grow to be a really serious competitor of coal on account of the small quantities of gas available. No estimate of the quantity of gas stored in the earth can be made with great confidence. Many people will recollect cases in which well-informed scientists have made incorrect predictions of early exhaustion of our oil and gas resources. These experiences make us suspicious of such opinions; however, most of the estimates of our gas reserves point to a fairly long life for them. For example, the resources of the Texas Panhandle alone are estimated at 7200 billion cubic feet at 80 per cent recovery. Even if the gas supply disappears in a few decades, the visible supply will last long enough to amortize quite expensive pipe lines if the gas can be transported to a reasonably profitable market.

In general, the condition that prevents natural gas from growing into a noticeable competitor of coal is a high price at its market or else unreliable pipe-line service. The latter especially must be avoided, since the great bulk of gas prevents its being stored in any great quantity outside the well. Both of these condi-

tions depend greatly on our ability to solve the engineering problems of the pipe line, for to reach most markets transportation by long trunk line is essential.

A striking example where pipe-line expense is avoided by moving the market for gas into the gas fields is found in the carbon-black industry, whose product is consumed mostly in the manufacture of automobile tires, paints, and printer's ink. Because its plants are always at the gas fields, the center of this industry shifts about, having recently moved from the Monroe, Louisiana, field to the rich Amarillo, Texas, district.

In most cases, however, pipe lines hundreds of miles long are needed to connect gas fields with industrial markets. The states producing the most natural gas, listed in order, are Texas, Oklahoma, California, Louisiana, West Virginia, and Pennsylvania; however, Texas and California consume a large part of their own production, thus making the largest volume of gas transported outside its state of origin flow from West Virginia to Ohio industrial centers. The second largest volume flows from Oklahoma to Kansas.

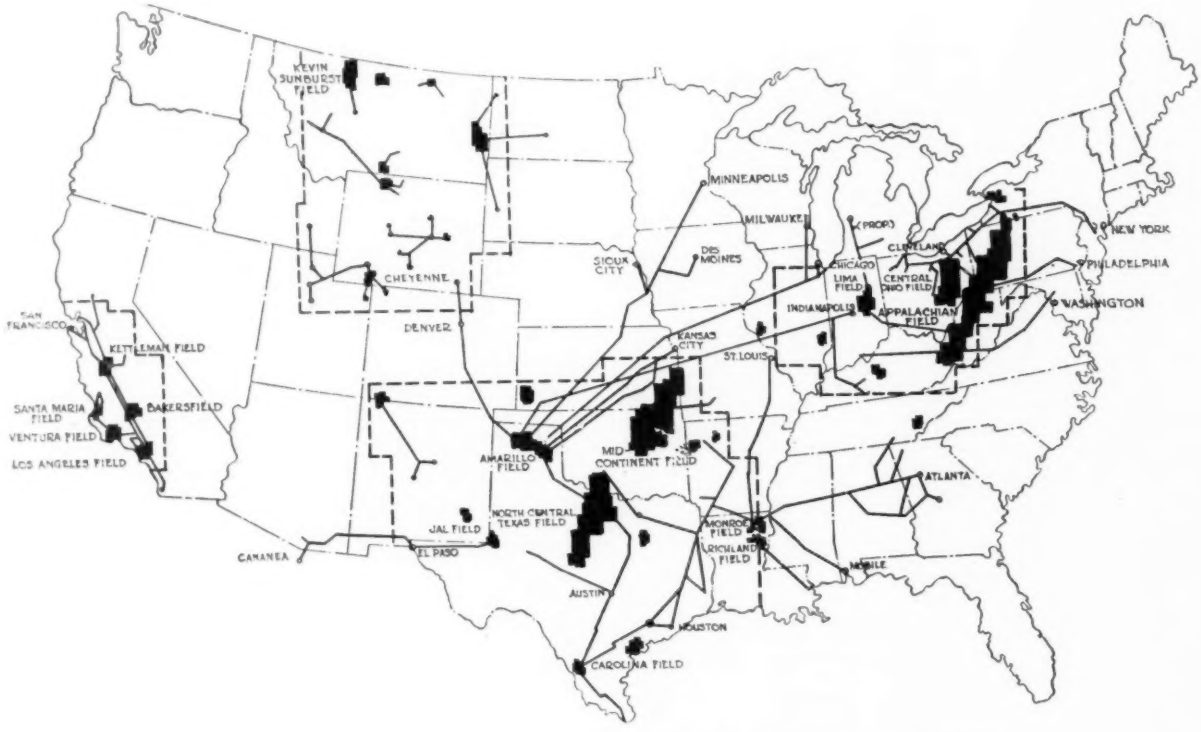


FIG. 4 SOME OF THE PRINCIPAL NATURAL-GAS PIPE LINES IN THE UNITED STATES

DISTANCE OVER WHICH A GAS PIPE LINE CAN BE OPERATED WITH PROFIT

The distance over which gas pipe lines can be operated with profit depends of course on many commercial factors, including competition; however, many of the existing lines are not only long and expensive, but run into territory well supplied with other fuels. Since August, 1931, Chicago has been able to secure about 175 million cubic feet a day from the Texas Panhandle through a 24-in. line 1000 miles long; Atlanta is receiving gas from northwestern Louisiana through a 22-in. 450-mile line; St. Louis has a 22-in. 430-mile line from the same source. Apparently, 500 miles over fairly difficult country is not too far to carry gas into many markets. Even through country full of natural obstacles, 350 miles is not too long. For example, the Amarillo-Denver 22-in. line carries natural gas deep into the Colorado coal regions, although many of its 340 miles run through rough and inaccessible country, rising 4200 ft and crossing such difficulties as a canyon 600 ft deep with sides sloping 45 deg. Its cost is stated as $25,000,000.

Thirty of the states of the union are now reached by gas trunk lines. Through these systems 19½ per cent of the total natural-gas production was taken out of the state of origin in 1930. The trunk-line mileage in the various states is shown in Table 3. To this mileage, about 10,000 miles were added up to July, 1931. In the past year some 250 million dollars were spent in im-

TABLE 3 NATURAL-GAS TRUNK-LINE MILEAGE, JULY 1, 1929

(Data from U. S. Bureau of Mines)

	Miles		Miles
Texas	7,800	California	1,600
Ohio	6,100	Arkansas	1,200
Pennsylvania	5,200	Kentucky	1,000
West Virginia	4,000	New York	1,000
Oklahoma	3,700	Wyoming	900
Kansas	3,500	Others	3,000
Louisiana	1,800		
		Total	40,800

(The estimated trunk-line mileage, July 1, 1931, was 50,000.)

proved gas distribution. Such rapid expansion is certainly strong evidence of the economic desirability in many locations of natural gas transported through long pipe lines.

GASOLINE PIPE LINES THE RAILROADS' GREATEST FEAR

The oil pipe lines introduce quite a different kind of competition. Until very recently, such lines were built almost exclusively to transport crude oils from the field to refineries, the latter being located near low-priced fuel and enjoying cheap transportation of finished products. The lines were undoubtedly quite profitable investments; in fact, the low cost of transporting crude oil by pipe lines prevented competition by railroads except in unusual cases. The growth of crude-oil lines has been largely dependent on the rate of production of crude oil, and has been steady and not very spectacular. Such lines have, however, been developed into a 100,000-mile network such as is found nowhere else in the world.

But the monopoly of the crude-oil line ended at the refinery. Finished products were distributed by barges, tankers, motor trucks, or by some 150,000 railroad tank cars. How important this tonnage was to the railroads is shown by the fact that in 1929, Interstate Commerce Commisssion reports showed petroleum products furnishing 20 per cent of the carload-lot freight revenue secured from Group V, Manufactures and Miscellaneous. Of this revenue from petroleum, 77 per cent was from gasoline and similar refined products. In that high percentage is found one of the present-day troubles of the railroads, for two years ago engineering progress had made the long pipe line seem an economical method of transporting gasoline; and in that year plans were made for several long pipe lines especially designed to carry a goodly part of this tonnage. Any reduction in coal consumption due to natural gas will also probably reduce railroad revenues somewhat, but of the two types the gasoline pipe line is the railroads' greatest fear.

Short gasoline pipe lines have existed since 1923, when a 17-mile line was run into Los Angeles harbor. The first really long one was built in 1927, when the Shell Company built a line 97 miles long through rough California terrain and pumped gasoline through it with centrifugal pumps at pressures above 600 lb per sq in.

The engineering problems peculiar to the gasoline pipe line are the risks of leakage in transit and of evaporation losses in tankage. By 1930, however, both the natural-gas and the crude-oil lines had amply demonstrated the possibility of securing tight lines by arc and gas welding, and the improvements in the efficiency of centrifugal pumps had made these units acceptable. Through their use the pipe-line engineer could minimize evaporation losses by eliminating surge tanks; and where tankage was actually needed, modern spheroidal or floating-top tanks were available. It is true that before 1930 very few data existed on the hydraulic behavior of gasoline in large pipes; but on the whole, the possibilities of such lines were most attractive.

The first concern to actually complete a major gasoline line was the Phillips Pipe Line Company, which in August, 1930, began to connect Borger, Texas, with East St. Louis, Illinois, through 681 miles of 8-in. welded pipe. The construction of this line required about 50,000 tons of steel pipe. Through it five grades of light fuels will be pumped, ultimately at the rate of 30,000 barrels a day. This quantity is equivalent to about 150 tank-carloads a day.

One of these five fuels is butane, a very common high-volatile product of natural-gasoline recovery plants, and a fuel for which a considerable market has grown up. It is an excellent enricher for municipal gas plants, and both it and propane are also to be sold, under the name of "bottled gas," in cylinders under pressure as a domestic fuel for gas stoves in rural districts. The Phillips Company will draw the fuel supply for its pumping stations from the slugs of butane pumped through this line between slugs of gasoline. The power used in these stations comes from four-stroke-cycle gas engines which drive four-stage 3500-rpm centrifugal pumps through geared speed increasers.

A few months after the Phillips line began delivering fuel, the longest gasoline pipe line in the world was finished. This line, of the Great Lakes Pipe Line Com-

pany, a cooperative association of six companies, extends from Oklahoma to Des Moines, whence one branch leads to Chicago and another continues north to Minneapolis. It comprises 1400 miles of 6-in. and 8-in. pipe, and cost $17,000,000. It will transport two grades of gasoline pumped by Diesel engines driving reciprocating pumps, with two floating-roof tanks at each of the 22 pumping stations. Both the Phillips and the Great Lakes lines cross some of the widest rivers in the United States.

Not all of the long gasoline lines are in the West, however. Last June the Sun Oil Company pumped gasoline from near Philadelphia to Cleveland, a distance of 492 miles, through the 8-in. western branch of its Y-shaped system. The other branch is a 6-in. line running north to Syracuse. Both branches are gas-welded seamless pipe, with motor-driven centrifugal pumps in the stations. At one point a 900-lb line pressure is carried. These lines run through thickly settled areas and also connect with the excellent water routes found in the Ohio valley rivers, the Great Lakes, and the Erie Canal. One interesting section of the line was laid in the bed of a river to avoid the earth movements common along the banks, which were underlaid with old coal mines.

ENGINEERING PROBLEMS INVOLVED IN THE ECONOMICAL TRANSPORTATION OF FLUID BY PIPE LINE

It must be evident that economical transportation by pipe line requires solving numerous engineering problems. In many ways these problems are similar, whether the fluid be gas or oil. Both substances cause the engineers to worry about the most economical pipe sizes and line pressures, most economical booster station spacing, the relative advantages of gas, oil, and electricity as pumping-station power, the relative value of rotary and reciprocating pumps and compressors, types of pipe and of pipe connections, corrosion, leakage prevention, river crossings, and the like.

Especially in construction methods are the problems fundamentally alike, though the oil line uses pipe 12 in. in diameter or less under fluid pressures of about 700 lb and the gas line employs pipe of about 24 in. diameter or less carrying pressures of about 400 lb. The actual construction of such lines retains a good deal of the romantic interest once associated with new railroad construction. The buffaloes and Indians are gone, it is true; but at least one line built less than two years ago had to provide machine guns and tear gas to protect its workers from the modern type of organized brigand. The routes often include plenty of natural obstacles, swamps and rocky cliffs, mile-wide rivers and the Continental Divide, rich farm lands, and waterless deserts. In the early days reconnaissance parties took months to select a route, and then could not guarantee that they had a complete picture of conditions. Today an aerial photographic survey secures in a few weeks or days a map which shows every detail—water courses, improvements, communications, even soil conditions. With this information as a basis, the line is routed, profiles run, stations located, and pipe and machinery ordered. Then the engineer and the contractor plan means of transporting materials and housing workers. They schedule their operations with the same sort of care that goes into the planning of an army offensive. With work once started, modern explosives clean out rock in short order, and a battalion of pipe stringers, welders, pipe coaters, backfillers, telegraph men, and the like, supplied with dozens of automobile trucks, ditching machines, and tractor winches, run up progress in terms of several miles a day. Mud, floods, and cold slow them up, of course; but some remarkably fast time has been made. For example, 80 miles of 8-in. welded line was laid last summer through rocky Oklahoma hills and across two rivers at a rate of about $3\frac{1}{2}$ miles a day.

Occasionally no ditching need be done. For example, in laying a 12-in. gas line between Mobile and Pensacola last year, many miles of ground were met which would not support animals, welding equipment, or any of the usual machinery of the pipe liner. The only solution to this situation was threaded pipe, carried in and made up by men wading deep in muck, with all pipe joints enclosed in heavy river clamps and with the line left to sink or float, as it preferred.

Most pipe-line construction is of course done in the summer,

and as a result the pipe, which is hot when laid, contracts considerably after the ditch has been backfilled. The resulting tensile strains and pipe movements can be avoided more or less by laying the pipe from side to side of a wide trench, thus providing slack to be taken up during cold weather. Other more modern methods include forming a circumferential wrinkle at one or both ends of each length of pipe, or of providing lost motion in couplings of the clamp type.

One of the most interesting problems met during construction is that of crossing a river. Almost every conceivable solution has been used. The most common method connects headers on opposite banks with a number of pipes laid in trenches cut in the river bottom. Often these pipes are arched upstream, with the headers

PIPE LINE TRAVERSING DIFFICULT COUNTRY

firmly anchored into the banks by piling. All pipe joints are made up with special care, the welded joint being reinforced by straps of steel welded along the pipe and across the seam. A heavy iron river clamp is also usually bolted over all kinds of joints, serving both to strengthen the connection and to overcome the pipe's natural buoyancy. (An empty line 10 in. in diameter or larger will float in water.) To get these lines across the river, they may either be built up on the bank and pulled across by men with block and tackle or by tractors or locomotives; or the 40-ft lengths of pipe may be fastened together on a barge, each additional length of pipe pushing the vessel farther across the stream as the line is shoved down an incline into the water. Most of the large rivers of the United States have been crossed by pipe lines buried in their beds.

Another method uses bridges. Wood and concrete trestles have been tried; and in one unusually fortunate case a 22-in. gas line running from the Texas Panhandle to Indiana found it possible to cross the Mississippi on a steel highway bridge already built at a convenient point.

Any river crossing must of course neither wash out nor impede traffic in a navigable river, and in a number of cases high suspension bridges have solved the problem. The first instance of their use was in 1925, at a point on the Red River in Texas where the ordinary buried crossings of a gas line had repeatedly given trouble. A dozen or more suspension bridges have since been built in Texas, one of them supporting four 12-in. gas lines and a walkway. In such construction the problems of pipe expansion, wind load, and horizontal swing must of course be considered. On all bridges for oil pipe lines the line proper is usually enclosed in an outer pipe to prevent leakage from contaminating the stream below.

A third possible method of carrying pipe lines across streams is the tunnel. At least two of these exist, the last one, just completed, crossing the Houston ship channel. The tunnel was favored here because proposed deepening of the channel requires that any pipe trench excavated shall extend 15 ft below the present bed, and because traffic rules prevent stopping ship movements more than four hours, with the obstructor liable to damage suits from owners of delayed ships. This 600-ft concrete-walled tunnel will accommodate a number of future pipe lines, will allow repairs to be made easily, and will avoid trouble from pipe strains or corrosion. It was built by the pneumatic method at a depth of 66 ft below low tide.

PREVENTION OF PIPE AND TANK CORROSION

Another field for improvement with great opportunities for economy is that of the prevention of pipe and tank corrosion. Sometimes the life of buried steel pipe is only a year or two; often it is less than fifteen years. The many forms of pipe protection which have been tried include aluminum foil, greases, pitch and asphalt, felts, papers, and various fabrics. Soil stress damages them all; and no commercial method known at present is thought to protect with certainty steel in bad soils more than five years. All methods are expensive to

apply either at the pipe mill or in the field; however, protection is so important that all modern lines use a great deal of coating and wrapping, and many of the pipe lines run soil tests ahead of the connection gangs to determine the degree of protection needed. This problem of soil corrosion is being attacked in a very systematic way through a cooperative plan supported by the American Petroleum Institute, the U. S. Bureau of Standards, and the major oil-pipe-line companies. The American Gas Association is also doing research of this character.

Space will not permit a discussion of the advances made in the last few years in welding, or of those improvements in line pipe which have brought its strength up from 48,000 lb per sq in. to 70,000 lb per sq in., although such improvements are very largely responsible for the cheapness of the more modern lines. Improvements in automobile trucks and tractors have also cut the cost of line construction and have increased its speed tremendously. Fortunately for the general public, such engineering improvements are far from at an end, and further reductions in the cost of transporting oils and gas by pipe line can be expected with confidence.

How the railroads and coal producers can combat this development is not very apparent. History is full of cases where a really improved method has quickly taken the market from other agencies; and the losses of private individuals or even of whole industries or whole trades have seldom retarded such movements for long. A century ago the introduction of railroads resulted in making the gilt-edged bonds of canal companies almost worthless, and appeals to legislatures had small effect in delaying the operation of this natural tendency.

Ewing Galloway, N. Y.

CATERPILLAR TRACTOR HAULING WELDING EQUIPMENT

PIPE-LINE DEVELOPMENTS

Whatever occurs to the ownership of the pipe lines, their continued expansion seems unavoidable so long as the nation continues to develop. Perhaps they will not continue to carry their present contents. Already lines originally carrying Pennsylvania crude eastward to seaboard refineries have been put to work carrying gasoline westward from those same refineries, and the natural-gas lines may easily some day carry artificial gas from mine-mouth producer stations back toward the one-time natural-gas fields. Solid fuels in suspension may some day be a promising pipe-line load, and so may certain chemicals or even some foods. Many conditions point to a continued cheapening of pipe-line operation and to a growth of the present-day demand for various liquid and gaseous fuels. So long as such demands can be satisfied cheaply by the pipe lines, their network will continue to operate as a very useful part of the nation's transportation system.

The proposed entry of the railroads themselves into the pipe-line business will require considerable investment, and it seems doubtful whether the net profits on these sums would counterbalance to any great extent the railroad's losses due to their decreased tank-car revenues. Moreover, though the pipe lines now in the hands of the oil companies have doubtless been profitable enterprises, it is a question whether independent pipe lines would secure sufficient patronage to develop a profitable load factor. In theory, all the existing pipe lines are common carriers and must transport any one's oil between points on their systems; but in practice today enough restrictions are allowed them in terms of minimum quantities accepted, fuel grades carried, storage capacity provided, etc., to practically restrict the pipe line to the carriage of the oil it wishes to take. This load it handles in the most profitable manner for all parties concerned. The independent pipe line would almost certainly find difficulty in securing the close cooperation between producer, carrier, and refiner existing where these three activities are under one direction.

CAPILLARY BEARING LUBRICATION

By ALVIN EDWARD MOORE[1]

IN THE past few decades, bearings have evolved from the plain, friction type to the roller-bearing type, but many competent observers are now following with great interest recent developments in the plain bearing. There are many factors in favor of the plain bearing, including cheapness and simplicity of design. The United States railroads have never forsaken it, and at present railroad engineers are intent on the problem of its more effective lubrication, in order that it may better compete with the new anti-friction type of locomotive bearings such as those exhibited at the recent convention of the American Railway Association. As a result of practical experiments, one engineer goes so far as to state that if the plain bearing is properly lubricated, it is practically as efficient as the anti-friction type.

Surveying the art as a whole, the author is inclined to agree with this engineer. In Germany, France, England, and the United States, practical inventors are continually working on this problem of the lubrication of the plain bearing, and if their combined efforts evolve a more satisfactory means than the present "brass" and cheap journal-box waste, the anti-friction bearing concerns will have much keener competition.

Several years ago it was discovered that renovated waste from railroad bearings was more efficient than the new waste just purchased from the textile factories. A study of journal bearings revealed the fact that in new waste each fiber has clinging to it an amount of fine lint. The oil in the journal boxes carries these fibers to the top, where they produce dense mats which exclude the lubricant from the journal, thus causing hot boxes. Treatment of the renovated old waste by bathing it in hot lubricating oil to remove impurities eliminated these fibers, thereby making a better product. The treatment of new waste with hot oil before it is used for packing railroad bearings has thus been introduced.

A like method of removing obstructions to the capillary passage of oil through the pores of wood has also been developed. For years experimentation on the problem of lubricating trolley wheels by the use of wooden plugs inserted in bushings had been more or less unsuccessful, due to the fact that coarse-grained woods fed too much oil, and light-grained, so-called non-porous woods, such as pine, fed too little. It was finally ascertained, however, that the resin in the microscopic pores of pine wood obstructed the passage of oil, and eventually there was discovered a method of removing the resin by boiling the pine in oil. Plugs treated in this manner were found to feed exactly the right amount of oil. Pulleys and also journals and locomotive bearings have been lubricated by means of such treated plugs. Last year the American Railway Association made a rather favorable report on this contribution to the art of lubrication.

In Germany there has been invented a new method of making microscopically porous rubber which will supply oil to bearings by capillary attraction. This rubber might replace waste to some extent but for the fact that oil is deleterious to all kinds of rubber that so far have been developed.

One of the most interesting recent developments in the field of lubrication of plain bearings is that of a porous capillary bearing metal. The material is a porous bronze, containing many very minute pores which absorb and supply oil by capillary attraction. It has been prepared for use in connecting-rod bearings, spring-shackle and valve lubrication, water-pump bearings, steering-rod bearings, and clutch pilot bearings.

This material will withstand pressures of 75,000 lb per sq in., and yet will absorb oil in an amount up to 40 per cent of its volume. If it is squeezed in a vise, oil will exude from the pores; if left in the sun, oil will seep out due to its increase in temperature. Its high oil content permits greater bearing loads than those carried by ordinary bearing metals. It may also be used to regulate a gravitational supply of oil, in the manner of the porous wooden plugs.

It is well known that during the first few minutes of operation of a machine, before lubrication is begun, the bearings wear proportionately much more than during the ensuing period of effective lubrication. For years engineers and inventors have tried to reduce this preliminary wear. This porous bearing material may provide the solution of the problem, since it would hold in its pores a certain amount of lubricant at the time the machine started.

This bearing metal might also render feasible an intermittent means of lubrication, such as the railroad centrifugal dipper and grooved "brass," or bushing, developed by various inventors in France, England, and Germany, and now making its appearance in this country.

Test plants are coming into use for determing the efficiency of plain bearings of varying design with different kinds of lubrication. At one end of a shaft, comparable to a railroad journal, the bearing is placed and subjected to its usual load. At the other end is a specially built calibrated motor.

By means of this machine and its instruments the performance of various bearings in speed, distance, horsepower-hours per mile, and bearing temperature is charted. From the data thus obtained, the relative efficiency of various bearing units may be determined. Such plants mark a practical beginning of a more scientific solution of this age-old problem.

[1] Patent Examiner, U. S. Patent Office, Washington, D. C.

REDUCING MATERIAL WASTE

By C. H. McKNIGHT[1]

THE fact that practically every factory process or machining operation involves some waste of material has tended to create the conception that all such waste is a natural by-product of manufacture. In other words, waste is just as inherent in design and manufacturing method as the material itself. It is an easy step from this point of view to one of resignation toward waste of productive material.

With the rapid introduction of labor-saving methods in recent years, labor has tended to become a decreasingly important element in cost. Machine tools have been designed more ruggedly in order that feeds and speeds may be increased in step with the advent of more efficient cutting tools. Wage-incentive measures, coupled with better factory layout and planning, have helped to synchronize factory production and increase the output per dollar of direct labor and square foot of floor space. And what effect has all of this progress toward lower labor cost had on material waste? It has made it easier than ever before to waste material, and at the same time opened up possibilities for its reduction on a larger scale.

It is only natural that after driving so long in one direction for increased output and the cost reductions obviously derived, that we should now go back and seek to balance the equation, on one side of which stands material waste and on the other such factors as labor and tool-development cost.

Waste in the factory is not a matter of sentiment. It is strictly a matter of cost. The jobbing shop will always be somewhat handicapped, but repetitive production lends itself to serious and profitable consideration of waste, because repetitive waste may be capitalized over a period of time and the savings effected used to finance far-reaching changes in design and manufacturing process.

RESPONSIBILITY FOR MATERIAL WASTE

Fundamentally, the responsibility for material waste rests with the designing engineer and those responsible for manufacturing methods. The designer is limited by the extent of his knowledge of the most up-to-date manufacturing methods, just as the manufacturer is limited to producing exactly what is called for by drawings and specifications. No real progress toward waste reduction can be made until design and manufacture are thoroughly coordinated. It is the purpose of this discussion to offer a few practical suggestions which have been found to be helpful in bringing about a better conception of material waste in its relationship to cost, and in stimulating active cooperation between engineer and factory with its reduction in view.

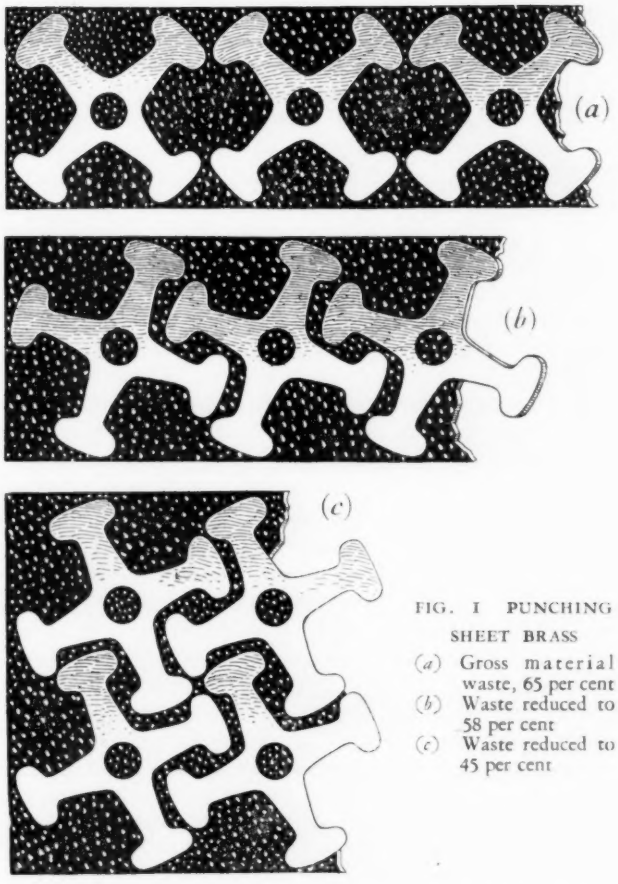


FIG. 1 PUNCHING SHEET BRASS
(*a*) Gross material waste, 65 per cent
(*b*) Waste reduced to 58 per cent
(*c*) Waste reduced to 45 per cent

Let us start in the factory, where it is common to regard scrap as a necessary evil—something with a value little more, if any, than the expense necessary to collect, segregate, and transport it. In other words, a problem for the salvage department. The average salvage department, using its best efforts, obtains a return from the sale of waste product equivalent to 2 per cent of the value of the factory output of finished product, and this is the accepted measure of the importance of the waste problem.

An analysis of the incoming and outgoing freight in ten representative plants gave the following average results:

Annual incoming productive material		78,000 net tons
Annual outgoing finished product		62,000 net tons
Difference		16,000 net tons
Difference as above (total waste)	16,000 net tons	
Scrap shipped	12,500 net tons	
Unaccounted for in shipments	3,500 net tons	

[1] Supervisor of Waste and Spoilage, General Electric Co., Schenectady, N. Y.

Ratio of total waste to incoming material	20 per cent
Value of productive material purchased	$10,000,000
Average material shrinkage of 20 per cent	$2,000,000
Scrap sales	400,000
Net loss (16 per cent)	$1,600,000

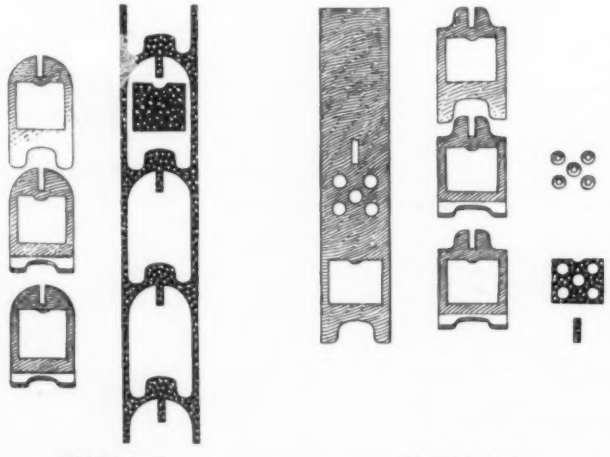
NOTE: Waste unaccounted for was delivered to dump, incinerator, or sewer.

The net loss of 16 per cent of the material purchased offers a striking contrast as a measure of efficiency in the usage of materials to that derived from a study of scrap sales. On the other hand, statistics of this kind serve little purpose other than to open our eyes to the magnitude of the waste problem. The same thought must be carried down to the individual job in order to point the way to practical methods of reducing material losses.

Every job in the factory, whether it be a simple lathe operation or a complicated process, lends itself to an analysis of waste in relationship to all of the other factors making up the shop cost of the product. It is not uncommon to find whole lines of product in steady production as the result of a gradual increase in sales over a period of years. When the design was originated and placed in the factory the initial production outlook was small. Consequently, the simplest kind of tools were made in order to minimize the development charges to be spread over a relatively small output. And so gradual has been the increase in production and so accustomed has the shop grown to a certain amount of waste, that it is accepted as unavoidable.

METHODS THAT HAVE BEEN INSTRUMENTAL IN REDUCING MATERIAL WASTE

Among the accompanying sketches, Fig. 1 is a case in point. This part as originally punched from $\frac{1}{8}$-in.

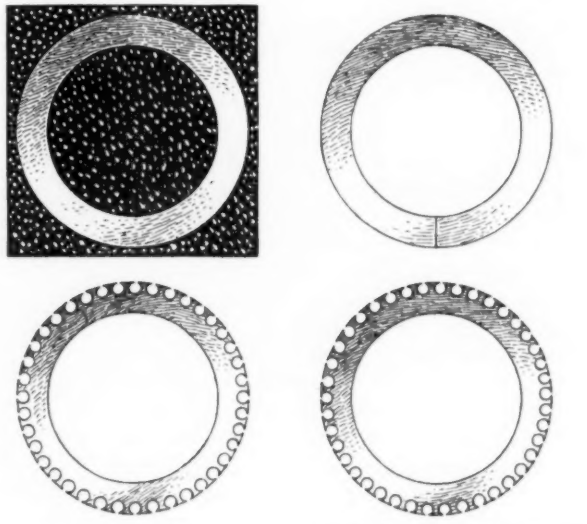


Old Method New Method

FIG. 2 SAVING EFFECTED BY REDESIGN OF PUNCH

sheet brass (*a*) carried a gross material waste of 65 per cent. A year's material requirements amounted to $7200, of which $4680 was wasted. A new alignment of the die (*b*) was considered, which reduced the waste to 58 per cent. The cost of making a double die (*c*) was investigated, and it was found that it would pay for itself in less than a year by reducing the waste to 45 per cent. Incidentally, the material specifications were changed by the engineer as a result of his interest's being awakened by the changes in die construction, and in the end the overall cost of the part was reduced nearly 50 per cent.

Fig. 2 also illustrates what may be done to save waste at the punch press. This nickel-silver part as originally punched was wasteful as shown by the scrap outline.



Punched Edgewise Wound Without Waste

FIG. 3 EDGEWISE-WOUND RIBBON STOCK SUBSTITUTED FOR FLAT RING PUNCHING

An ingenious change in design made the forward contour conform with the rear contour, thereby permitting the construction of a simple follow die, reducing the punching time, practically eliminating waste, and giving five small washers as a by-product.

Fig. 3 shows the application of edgewise-wound ribbon stock as a substitute for flat ring punchings which are necessarily very wasteful. In this case a soft-copper strip is wound edgewise, cut off, and the peripheral holes punched as a final operation, the hole punching constituting the entire waste.

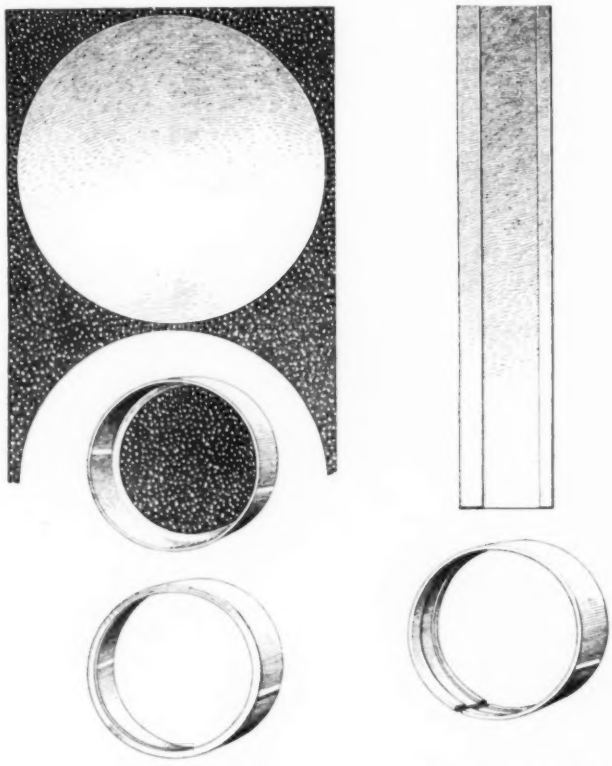
Fig. 4 illustrates a shell fabricated from strip steel and welded. This process proved economical both as to material and labor.

Fig. 5 represents the application of the cold-pressed copper-forging process as a substitute for drop forging. The waste in flashing is entirely eliminated.

Fig. 6 shows a steel shell produced on a 4-spindle automatic screw machine. As originally designed, this part called for 8 lb of steel. In an effort to find a less wasteful process of manufacture various methods of fabrication were investigated, such as malleable castings, forgings, and seamless tubing. The high cost of individual chucking for finishing made the overall cost of individually fabricated parts uneconomical. The investigation finally led to a change in design calling for

5.4 lb of steel, making a material saving of 32 per cent.

Fig. 7 shows an application of the hot-pressed forging process as a substitute for sand casting. The sand casting weighed 20 lb in the rough, while the hot-pressed brass forging weighed 13 lb. The economy governing this change lay in several directions, viz.,



Drawn Steel Shell — Same Part Fabricated Without Waste

FIG. 4 SHELL FABRICATED FROM STRIP STEEL AND WELDED VS. DRAWN STEEL SHELL

less waste, better strength for a given cross-section, less material to machine off, better machining qualities, and freedom from casting defects, discoverable only after machining. On a production of 1500 flanges per year, this change showed a saving of $2800 after paying for forging dies.

In practically all of the cases cited, both engineering and shop initiative are expressed. It is immaterial which comes first. The main consideration is to have the facts pertaining to material waste.

Different types of manufacture naturally lend themselves to different methods of approach. Certain fundamental principles apply, however, regardless of the character of production. First, there is the theoretical minimum waste inherent in the current design and manufacturing methods. This is determined from drawings or from tests made under ideal conditions. Secondly, there is the actual waste incurred in day-in and day-out production. The difference may be termed the marginal shop waste, and must necessarily be attacked through better material planning and closer shop supervision. Running records of actual waste plotted against theoretical waste will show trends for which the shop is responsible. Such records may be conveniently made in pounds, although it is well also to keep the dollars-and-cents viewpoint. This latter is done by evaluating all waste at the value of the material at the time it enters the process.

WASTE REDUCTION A QUESTION OF CHANGE IN DESIGN, TOOLS, OR PROCESS

Reduction of theoretical waste is clearly a question of change in design, tools, or process. The theoretical waste is also recorded in dollars and cents, evaluated at the first material cost, and serves as a constant reminder to engineer, superintendent, and foreman that in material waste there is ever present a potential source of reduction in cost.

It is not always easy to determine the theoretical minimum waste consistent with good quality of product. This is particularly true of process work where the human element may control the degree of waste. However difficult it may be to arrive at the least permissible amount of waste, it is nevertheless essential that this be done in order that the marginal waste may be determined.

Drop Forging — Cold-Pressed Forging

FIG. 5 COLD-PRESSED FORGING OF COPPER AS A SUBSTITUTE FOR DROP FORGING

It is possible for foremen to lose sight of the importance of waste and strive for labor efficiency at the expense of incurring a certain amount of material waste. An economic balance between labor and material is essential. In most

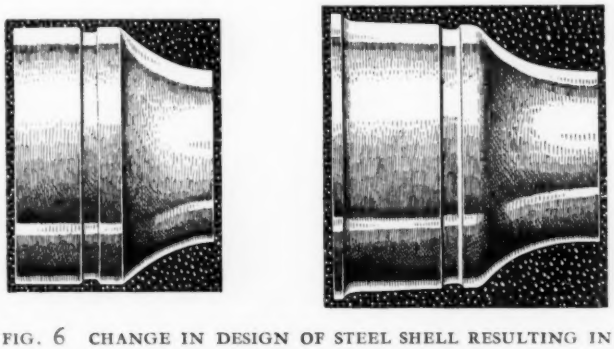


FIG. 6 CHANGE IN DESIGN OF STEEL SHELL RESULTING IN A MATERIAL SAVING OF 32 PER CENT

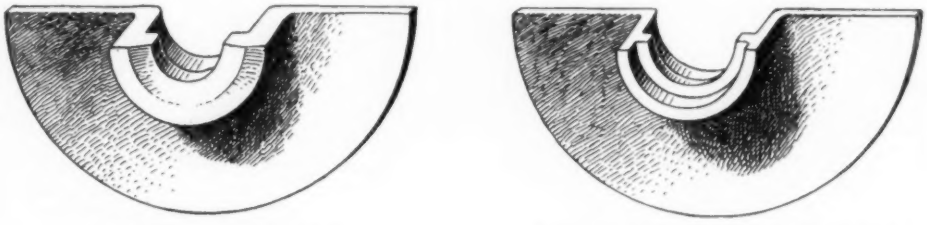
Right: Old design requiring 8 lb of steel; waste, 80 per cent = 6.4 lb
Left: New design requiring 5.4 lb of steel; waste, 79 per cent = 4.25 lb

cases the material efficiency should be raised to the highest possible point, from which point it is easier to work for improvements in labor efficiency than for better material efficiency after labor rates have been established on the basis of a speedy but wasteful set-up.

To obtain positive results in the reduction of so-called natural material waste, the responsibility for the proper presentation of the facts should be definitely assigned. The Cost Department, already responsible for the liquidation of material waste in cost, is in a good position to supply data on theoretical minimum waste, while the Salvage Department or a man specially assigned to the study of waste on the manufacturing floor can supply the data on actual waste. These data, presented with or without recommendation to those responsible for design and manufacture, provide the surest means for an attack on waste.

To the most skeptical mind, seeing is believing. There is no more effective way of bringing home the cold facts of waste than to lay out on a bench all of the component parts of a device, and beside these place the raw material required for the manufacture of each part and the actual waste incurred in the various manufacturing operations. It is hard to conceive of the imaginative stimulus a display of this kind will impart to the designer and manufacturing man. One can just see the mental wheels begin to turn and hear the questions shot back and forth. "Why do we have to do it that way?" "Why couldn't we do it this way?" And so it is that the elimination of avoidable waste in manufacturing processes is a very fundamental thing. It draws together the creative force of the engineer and the interpretative skill of the manufacturer. It opens the door to progress.

FIG. 7 HOT-PRESSED BRASS FORGING SUBSTITUTED FOR SAND CASTING



Sand Casting. Weight, 20 lb.

Hot-Pressed Brass Forging. Weight, 13 lb.

Diesel Engines

AT THE Royal Society of Arts, London, on December 7, H. R. Ricardo, F. R. S., delivering the third and concluding lecture of his course on the above subject, said he thought that in the development of the Diesel engine the history of the steam engine might, in part, be repeated. The early steam engines were slow-moving, dignified, and impressive. Then came the fast-running single-acting Willans engine, to be followed later by the still quicker-running double-acting Belliss engine, and this, in its turn, was superseded by the still faster turbine.

The high-speed Diesel engine he had in view would have piston speeds of over 1500 ft per min, and the cylinder diameter would be 8 in. at the most. He expected that, in the near future, Diesel engines of the slow-running type would be required only for special conditions. The high-speed type was fully as efficient, and there was a gain in horsepower and a reduction in weight, with the entire absence of temperature troubles. The aggregate rating of the gasoline engines now in service exceeded 300 million hp, or ten times that of all other power in the world. With mass production, high-speed Diesel engines would be produced quite as cheaply.

It had been claimed that the cost of maintenance would be excessive, and it was true that the high-speed engine would require more frequent overhaul than the slow-running type, but each overhaul would be much less costly, so that on the whole, the costs of renewals and maintenance would be less than it was in the case of the ordinary Diesel engine. In steam practice, large engines had been favored, as they were more efficient, but the efficiency of the Diesel engine was independent of its size, and he would advocate in place of the largest possible Diesel engine the adoption of the largest number of engines, each of the smallest possible size. There would be a gain in efficiency, since at partial load some engines would be cut out of action and the rest run at their most economical loads. The first cost would be less and the reliability greater. The arguments against a multiplicity of units were, he thought, unsound. It was argued that, on the procedure suggested, 1000 engines and 2000 valves would be required to take the load which a single large unit could carry, but even if 100 or 150 of the small engines were simultaneously out of order, the full load could still be taken. Indeed, since an overload of 15 to 20 per cent could be carried, as many as 200 or 300 of the engines could be simultaneously out of service without bringing matters to a standstill. On the other hand, a large steam turbine had thousands of blades, and the failure of a single one would throw the whole unit out of service. The chance of a simultaneous breakdown of 1000 Diesel engines was, of course, negligible.—From report in *Engineering*, Dec. 18, 1931, p. 767.

EXTREME-TEMPERATURE METALS[1]

Properties of the Metals Available for Such Exacting Service

By H. W. GILLETT[2]

SEVEN years ago, in 1924, the demand for information on high-temperature properties of metals brought The American Society of Mechanical Engineers and the American Society for Testing Materials together in a symposium in which the then available data were presented and discussed. The importance of the subject was so great that there was established, as a result of that first symposium, the Joint Research Committee on the Effect of Temperature on the Properties of Metals, with representatives from both societies. Its purposes are to foster study of the subject, to facilitate exchange of technical and engineering information on it, and to carry out research work on fundamental problems within the field covered by its activities. All these purposes are being fulfilled by work now under way.

The publications of the societies since 1924 have recorded, in papers and committee reports, the work accomplished by and sponsored by the Joint Committee. While the Joint Committee probably was the pioneer in concerted action in this field, engineers and scientists all over the world, spurred on by economic demand for information, have attacked the problem. Though the known data are still meager in comparison with the demand for them, such progress has been made that the time was evidently ripe for a summation of the present pressing demands of the engineer, and of what the metallurgist has produced toward meeting those demands. The Joint Committee and the sponsor societies therefore arranged a second symposium on the same topic which was held in Chicago, Ill., June 23, 1931. The papers and discussions presented on this occasion have been gathered into a single volume of a thousand pages.

The 27 papers that comprise the volume are largely compilations of data from many sources, domestic and foreign, but compilations by experts qualified to appraise and interpret the data of others as well as their own. The subject has been divided into two general sections, one dealing with the engineering trends and requirements for metals at high and low temperatures, the other with the properties of available metals for high- and low-temperature service. This volume, then, deals with the subject primarily from the engineering point of view.

Within the engineering fields covered by this symposium, the authors of the papers have had the task of summarizing the information contained in the extensive literature, of appraising it critically, and of adding unpublished information.

Not only are the more formal papers of interest, both as to the data presented and their critical appraisal, but the copious discussion has added much in further unpublished information and wise comment.

The keynote of the whole symposium is found in the opening paragraph of the first paper, where Kerr points out that the engineer, who now states immediate requirements which are still a bit ahead of what can be supplied, will make those requirements still more stringent in the future. It seems that the task of the metallurgist will be never-ending. His task is not over when he does find materials of the required properties, for Kerr points out that they must have good fabricating properties, and that they must be cheap enough to make it good economics to use them.

Yet first cost does not deter the user of alloys at high temperature, if their use means an overall saving. Several of the papers refer to large-scale use of an alloy containing 66 per cent Ni and 20 per cent Cr, and the inclusion of data on the platinum metals in this symposium seems inconsistent to no one, even though it is the engineering point of view that is being considered.

Bailey comments on the need for the elimination of the "mild-steel complex," and the willingness to utilize new alloys aimed to meet a particular problem.

Comment is made on the fact that very few of the alloys listed in the 1924 symposium as most promising for high-temperature service, have survived in 1931, but have been displaced by still better ones. While chromium and nickel are the vital elements in such a large proportion of the alloys mentioned for various purposes that they clearly overshadow all the other alloying elements in importance, the tendency toward embrittlement of the otherwise well-thought-of "18 and 8," as well as of the straight iron-chromium alloys, and the great amount of effort being put on the elimination of this fault, lead to the belief that some modification is likely to be met in such alloys. Comment on the marked and specific benefit conferred upon the high-temperature properties of carbon and various alloy steels by the introduction of molybdenum or tungsten, particularly the former, occurs in so many of the papers that increased commercial attention to and use of molybdenum alloys is clearly presaged.

Now that it is known that the nitriding steels and the nitride case have excellent high-temperature properties, they too will call for more attention. Brief reference to

[1] Abridgment of preface to "Symposium on the Effect of Temperature on the Properties of Metals," presented at a joint meeting of the A.S.T.M. and the A.S.M.E. in Chicago, June, 1931, and published in book form February 1, 1932, by the two societies. Price, $6 (to members, $5.50).

[2] Director, Battelle Memorial Institute, Columbus, Ohio, and Chairman of Symposium Program Committee.

"Konel" which bids fair to show outstanding creep resistance, brings cobalt also into the picture.

One thing is very obvious in all the papers: every one expects a change in the alloys used for almost any high-temperature service. Boegehold and Johnson indicate that the automotive engineer would be receptive to beryllium-aluminum piston alloys when they are made available for his use, and they definitely prophesy the passing, for severe service, of the present group of babbitt metals and their replacement by new types of bearing alloys.

Any one who fears that the national engineering societies which are standardizing materials and methods of testing, and putting out specifications and recommended practices, are causing stagnation, need only read this symposium to realize through what a state of flux the development of an alloy must pass while it is in the research stage, prior to the establishment of purchase specifications, and how far from sacred even an accepted specification would be if it were not promptly revised to represent the best information on the subject.

That much further research is needed is brought out by the fact that almost all the high-temperature data on cast iron and on many aluminum- and copper-base alloys, for example, are based only on "quick-pull" tensile tests.

Yet how far the quick-pull test may come from representing the long-time facts, is clearly shown by the curves on several pages as well as by comments on many others. Spooner and Foley find enough data obtained by long-time tests on the low-alloy steels so that they discard entirely all quick-pull tests as of too little value to cite. However, the fact is brought out by others that, up to temperatures where strain-hardening effects are rapidly removed by the annealing effect of the temperature, or where recrystallization of a cold-worked metal occurs, the short-time data, properly correlated with some creep data, do give useful information.

While many papers express an implied or an explicit desire for an accelerated creep test, there is a general feeling that the "little knowledge" obtained by the various short-cut methods so far brought forward "is a dangerous thing," and because such methods purport to give data truly representing long-time behavior, the terminology used is likely to mislead the engineer into taking the data for design purposes without the necessary grain of salt.

The warnings of Bailey and of Chevenard that it is still prudent to draw conclusions only from truly long-duration tests indicate that careful foreign thought is in agreement with the cautious attitude of most American investigators.

It is pointed out that even with the most careful testing procedure it cannot be assumed that the results of tests of a single heat necessarily truly represent the characteristics of all material of that composition. That foundry practice governs the high-temperature service of cast alloys as much as the alloy composition does is clearly brought out by Bull and by the discussions of McCormick and Brown.

Realization that large crystal size, as in a cast structure as compared with a forged structure, is advantageous for service at the higher temperatures emphasizes the fact that one must not be too ready to jump at general conclusions in regard to high-temperature performance on the basis of the analogies built upon room-temperature experience.

Care has to be taken not to draw too definite conclusions as to engineering design from laboratory tests, unless it is known certainly that the service conditions are adequately represented in the tests.

The tendency of some workers to refer to a "creep limit," based on their own requirements and the precision of their particular set-up, complicates interpretation of published data. As far as possible the data cited in the symposium have been related to the precision of the test method so that the reader may not be misled.

As Chevenard points out, increasing doubt is being thrown on the existence of anything that can properly be termed "a creep limit," so that comparison is now more commonly made on the basis of some defined rate of creep, or of no perceptible creep within a certain precision of measurement.

Designing engineers should be a bit patient with the testing engineer. Even though the latter cannot yet always give the former a design figure that can safely be used directly, it should be remembered that the relation of service performance at room temperature to the standard tensile and other acceptance tests, determined by many decades of correlation after fair refinement in test methods was secured, calls for certain factors of safety that vary with the type of service. While the testing engineers are sifting their methods and slowly coming to some agreement on them, they may only be able to place a group of alloys in the correct relative order and to indicate the general order of magnitude of safe and unsafe loads and temperatures. Even that information is much better than nothing.

Long before the writer became a member of the Joint Committee, he admired the spirit of the cooperating societies, firms, and individuals, for the firms and organizations with which many of the past and present members are connected have shown a most forward-looking attitude in exchanging information and in allowing their laboratories to perform very expensive tests on whatever part of the cooperative program was assigned to them, pooling all the data. Many firms not directly represented on the Committee have also cooperated whole-heartedly and unselfishly. While there is little formal cooperation among different countries in this work, yet workers in each country owe a debt of gratitude to their foreign friends for the publication of results. There are few fields of engineering or metallurgy in which workers follow as closely and utilize as promptly the results of foreign investigations as in this field of high-temperature properties. The inclusion of papers in this symposium by English and French engineers is only one sign of the international interest in the subject. Active international cooperation would certainly be welcomed and participated in by American workers.

DREAMS COME TRUE

Musings Prompted by a Visit to a Great Engineering Work

By F. V. LARKIN[1]

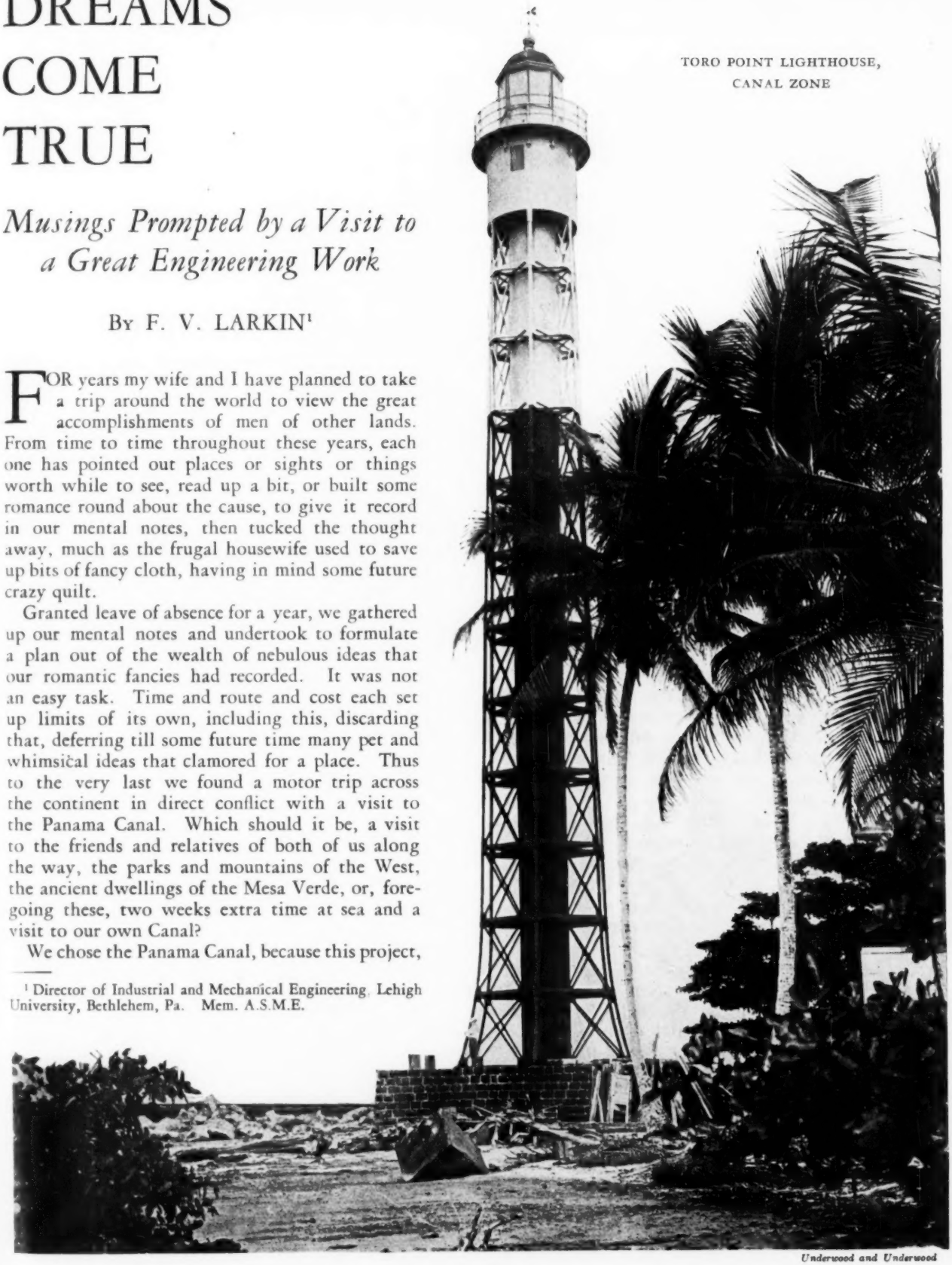
FOR years my wife and I have planned to take a trip around the world to view the great accomplishments of men of other lands. From time to time throughout these years, each one has pointed out places or sights or things worth while to see, read up a bit, or built some romance round about the cause, to give it record in our mental notes, then tucked the thought away, much as the frugal housewife used to save up bits of fancy cloth, having in mind some future crazy quilt.

Granted leave of absence for a year, we gathered up our mental notes and undertook to formulate a plan out of the wealth of nebulous ideas that our romantic fancies had recorded. It was not an easy task. Time and route and cost each set up limits of its own, including this, discarding that, deferring till some future time many pet and whimsical ideas that clamored for a place. Thus to the very last we found a motor trip across the continent in direct conflict with a visit to the Panama Canal. Which should it be, a visit to the friends and relatives of both of us along the way, the parks and mountains of the West, the ancient dwellings of the Mesa Verde, or, foregoing these, two weeks extra time at sea and a visit to our own Canal?

We chose the Panama Canal, because this project,

[1] Director of Industrial and Mechanical Engineering, Lehigh University, Bethlehem, Pa. Mem. A.S.M.E.

TORO POINT LIGHTHOUSE, CANAL ZONE



Underwood and Underwood

De Cou, From Ewing Galloway, N. Y.

S. S. "SAMARIA" IN MIRAFLORES LOCKS, PANAMA CANAL

thirty years ago, had furnished the inspiration that impelled me to become an engineer. For fifty years and more it had offered defiance to all engineers. Its heroic challenge had been accepted by engineers just as I was preparing to enter college. At that time the method of attack was shifting from a purely engineering one to one that included adequate sanitation. One courageous doctor had already sacrificed his life; a vigorous administration had acquired the right of way; doctors and engineers were publishing descriptions of their plans; and I, fired by the challenge which had stood so long, seeking escape from the fields of medicine or law and thrilled with the thought of being one of those to take part in achieving this stubborn task, worked out alone a clean-cut and firm resolve to be an engineer.

My training, my social background, and the traditions of our mid-western farming region hardly gave support to such a choice, and my conclusion received, at most, from friends and family, feeble and lukewarm support—rather an expression of curiosity as to what an engineering life entailed than the sound endorsement which would have been most valuable to me.

Thus doubt found lodgment in my boyish mind. Was I correct, would this great project to which I pinned my faith succeed? Could it make good if I did not? Conversely, but in positive form, it seemed to me that it could not possibly succeed if I did not. So for thirteen years I somewhat doubtfully burdened my subconscious mind with a great responsibility. Then the engineers themselves proclaimed the victory, and one great group of them held their mid-winter meeting at the scene of the construction, inviting the world to come and view the finished cut before the water was let in. Oh, I just had to join the group and go, and share the success which really was a part of me! But had I done my part? No one will ever know how desperately I longed and planned and schemed to go—it meant so very much to me. But all to no avail; babies were small, funds inadequate, job too insecure—it had to be postponed. And so, not caring to apprise my wife of these long-standing doubts, on promise of the motor trip at some propitious future time, I happily removed the last obstacle to a first-hand vision of my inspiration thirty years ago.

Self-confessed doubter and romanticist that I am, I too am a conservative, taught by experience that such as I, who weave fantastic halos round about the places which we long but never hope to see, too often suffer painfully when grim reality requires a toning down of our dream pictures to the humdrum drab of life. Then too, I've learned to know that self-proclaimed attainment of success usually blinds the announcer to those defects which less enthusiastic eyes are sure to find. And furthermore, I do regret that governmental projects, as has been my lot to see, too often lack the zest of true efficiency. And so as I approached the Canal—my inspiration thirty years ago—acclaimed successful by the engineers themselves, and operated under governmental sway, I must confess I viewed my picture through a darkened glass, for fear of disappointment at the very end.

We picked up Toro Light at dusk one glorious moonlight night, and with its intermittent help came safely through the harbor bar and anchored there. That night I scarcely slept at all. Had I been wise to come and let the curtain be withdrawn? By any chance unimaginable, could reality bear out the picture I had conjured up and loved for thirty years? And through the future years when, back to this inspiration of my younger days, I come to justify the work which I have done, to measure my accomplishment, to polish and renew the standards which have marked the way, must I be sentenced to a darkened glass, and never view again the shining, brilliant picture of my dreams? Better never to have come at all; and yet no permanent, real confidential happiness could there be for me until I myself had seen and measured up, and made evolutions of my own.

Next morning when we came on deck, seven o'clock found the lock crew and the pilot there. Up came the anchor and we were under way.

As we approached Gatun Dam, we saw the massive

man-made locks—three giant steps in a double row—securely and superbly set in a great hill, clean and green, and glistening in the morning sun, and at the very top—a rare coincidence I am told—a pair of ships, one bound each way, simultaneously in the topmost locks.

We did not stop; we just slowed down, and took the lock toward which a giant arrow swung. No word was said, no order of command, no whistle from the boat or siren from the lock; no gong, no sound at all was heard, as those on board stood breathless, thinking that the ship must strike. Meanwhile lock men lustily heaved out their lines, and in a moment, so it seemed, three lines of cable on each side were tightened with amazing speed by six bustling electric mules which ran in tandem, two abreast, on cogway tracks on either side. Standing high up on the after-deck, my farmer instinct came from out the past and took control, and I sensed again the thrill of reining up a spanking six-mule team with all its dignity and sense of power.

Within the lock, the great gates ponderously and precisely closed behind, and up we went, twenty-eight feet, the mules remaining patiently at ease, while I, the driver, as it seemed, paid out and kept an even tension on the reins. The front gates opened up and we drove in again, the mules sedately toiling up the hills with grace and energy superb. A third lock, lifting as before, brought us into Gatun Lake, created by a massive dam that backs the Chagres River up and sends its excess through a spillway to the sea.

Just as we unhitched the mules and started into Gatun Lake, we saw a structure such as we had never seen before—the emergency dam—made up of ponderous steel flashboards suspended from a swinging bridge which, on occasion, swings around and drops the flashboards into place, where they hold back the water of the lake, while the locks below are emptied of their water and thus laid open for inspection and repair.

Gatun Lake fills up the Chagres valley to the mountain range twenty-four miles away, and through this valley a channel course was possible with very little cutting. Then five miles of the Culebra Cut, right through the mountain pass, lets Gatun water through to the Pacific Slope. Then one lock down, the precise reversal of our lifting up, a mile in Miraflores Lake, formed like Gatun by damming up the river of that name, then two locks down, into Pacific water brought eight miles inland by a simple dredging cut. Forty-five miles across the narrow neck of land, in a direction south by east, in seven hours, arriving in the Pacific east of our Atlantic starting point, past Panama, Balboa, and the old ruined fort, and then dropping the pilot, and this never-to-be-forgotten trip was at an end.

The conception and the execution of this project are superb, massive, enduring, everything is clean and painted up, with no rubbish underfoot, no muddy pools, no plots of oil-killed grass, no weeds, no piles of junk or broken lumber to be seen, but instead clean red roofs white walls, green, well-kept lawns, plenty of space, waving palms, and open drainage ditches running clear; and beyond these the upland scene placid and green, with flowers and singing birds and not a single signboard to proclaim what motor fuel is wisely bought, what cigarette to smoke, or what shaving soap to use.

Although the group who daily operate this enterprise and furnish service to the shipping of the world are under Government control, happily I did not see the listless action that my doubts had conjured up—delay, red tape, and mediocre zeal, such as is sometimes manifest in groups who take their pay from Uncle Sam. Rather, I saw a clean-cut personnel—young men of energy and high morale—actors, it seemed, who timed their action to their work with such precision as to win the unacclaimed yet evident admiration of us all.

To other doubting engineers, if such there be, to young men in a quandary regarding a career, to parents like my own, who are not familiar with the engineering field: this is to say that I made a pilgrimage back to the inspiration of my younger days, and saw the vision of my dreams embellished in reality. I am satisfied. I know beyond the possibility of any future doubt or fear, that art, music, romance—all that signifies the spirituality of man—all are within the province of the engineer.

OIL TANKER IN GAILLARD CUT, PANAMA CANAL

Ewing Galloway, N. Y.

PROGRESS IN STEAM RESEARCH

Work Accomplished in 1931 in the United States and Abroad

DURING the recent annual meeting of the A.S.M.E. a session was held under the auspices of the Special Research Committee on the Thermal Properties of Steam to listen to reports presented by the investigators at work in this field under the sponsorship of the committee. Dean Arthur M. Greene, Jr., presided. A paper entitled "Thermodynamic Availability in Power Plants," by J. H. Keenan, of Stevens Institute of Technology, Hoboken, N. J., was also presented at this same session. It is expected that Professor Keenan's paper will be published in an early issue of MECHANICAL ENGINEERING. The reports are published in this issue.

The Special Research Committee on the Thermal Properties of Steam was originally organized in December, 1921, as a result of a need on the part of steam engineers for a more accurate knowledge of the thermal properties of steam under the higher pressures which were then coming into use. Accordingly researches were undertaken simultaneously at three institutions on different phases of the program: at Harvard, under Dr. Harvey N. Davis and Dr. R. V. Kleinschmidt, at the Massachusetts Institute of Technology, under Drs. F. G. Keyes and L. B. Smith, and at the National Bureau of Standards, under Drs. N. S. Osborne, H. F. Stimson, and E. F. Fiock. Funds for the work were generously donated by many industrial concerns interested in the results.

The Harvard data were assembled first. Wishing to make use of them as quickly as possible, the General Electric Company offered to perform the laborious task of reducing the test data to usable form. This work was done under the immediate supervision of J. H. Keenan, who, at the A.S.M.E. Annual Meeting in December, 1925, presented a total-heat–entropy diagram and a table of specific volumes based on these results.[1] In December, 1929, Professor Keenan presented a new Mollier diagram,[2] based on the Harvard data, that included the critical point. This was followed in January, 1930, by the publication of the Keenan Steam Tables.[3]

In the meantime, work at the Massachusetts Institute of Technology and at the Bureau of Standards has been progressing. For several years the February issues of MECHANICAL ENGINEERING have carried the reports of this work. Abroad, in England, Germany, and Czechoslovakia, similar investigations have been going on. Realizing the importance of a correlation of these numerous investigations, a conference of experts assembled in London on July 8, 1929, with representatives from Czechoslovakia, Germany, Great Britain, and the United States, and succeeded in agreeing upon skeleton tables[4] with tolerances within which any individual table would be considered as giving values of international acceptance. At a second conference held in Berlin in June, 1930, this skeleton table was revised. A third conference is to be held in this country early in the coming autumn.

Readers interested in recent researches in steam should consult the paper[5] by Dr. Davis and Professor Keenan presented at the World Engineering Congress, Tokyo, Japan, and the lectures[6] delivered in May, 1931, by Dr.-Ing. Max Jakob, at the University of London.

WORK AT U. S. BUREAU OF STANDARDS[7]

By NATHAN S. OSBORNE[8] AND H. F. STIMSON[8]

THE measurements of heat of vaporization at 50, 70, and 90 C, of which the results were presented a year ago[9] have been prepared by E. F. Fiock and D. C. Ginnings for publication in a more detailed record of observations, and will appear in the *Journal of Research* of the Bureau of Standards at an early date. These measurements were found to be in excellent agreement with the empirical equation based on measurements in the range from 100 C to 270 C. This experimental confirmation of extrapolation is not surprising in this range, where the change of latent heat with temperature is so small. On the contrary a similar confirmation in the range above 270 C, the upper limit of the observations, could scarcely be expected.

In last year's report[9] brief mention was made of the plans for new calorimetric equipment for extending the range of heat-content measurements on saturated steam beyond the 800-lb limit already reached with the existing apparatus. These plans have now taken tangible form in detailed design, construction, assembly, and operation of a complete new saturated-steam calorimeter. This prompt completion of the apparatus has been made possible by the fact that the entire

[1] See MECHANICAL ENGINEERING, February, 1926, pp. 144–151.
[2] Ibid., February, 1929, p. 109.
[3] "Steam Tables and Mollier Diagram," by Joseph H. Keenan, The American Society of Mechanical Engineers, New York, N. Y., 1930.
[4] See MECHANICAL ENGINEERING, February, 1930, p. 120.
[5] "Recent Research on the Thermal Properties of Steam," H. N. Davis and J. H. Keenan, MECHANICAL ENGINEERING, December, 1929, pp. 921–931.
[6] "Steam Research in Europe and America," by Max Jacob, published serially in *Engineering*, beginning July 31, 1931.
[7] Publication approved by the Director of the U. S. Bureau of Standards of the U. S. Department of Commerce.
[8] Physicist, U. S. Bureau of Standards, Washington, D. C.
[9] MECHANICAL ENGINEERING, vol. 53, no. 2, p. 137, February, 1931.

laboratory staff, including Drs. Fiock and Ginnings, has been able to engage effectively in the active instrument making. Otherwise it would have taken at least another year before the new experimental work could have been begun.

The calorimeter has been designed for the purpose of making reliable measurements of heat content up to 350 C and 170 atm pressure, but with extra allowance for withstanding pressure and temperature to permit extending this range of observations.

The principle of operation of the calorimeter is similar to that of the previous instrument and has been already described.[10,11] A number of details have been modified in order either to adapt the new design to the more severe range of conditions, or else to effect improvements indicated by experience.

Briefly restated, the calorimeter provides a place where a sample of water may be so isolated from other bodies as to enable its amount, change of state, and change of energy to be accurately accounted for. A quantity of water, part liquid and part vapor, is enclosed in a metal calorimeter shell. An electric heater immersed in the liquid is used to add measured energy. Outlets with valves provide for the introduction or withdrawal either of liquid or of vapor. Detachable receivers suitable for weighing are connected to the outlets to hold the samples of water transferred.

The calorimeter shell is well insulated from the influence of external sources of heat and cold. In operation, the temperature of an enveloping shell is kept very close to that of the calorimeter shell itself. The heat which passes to or from the calorimeter system is accounted for as a small correction which is determined.

Means are provided for observing the following quantities:

a Temperature of the calorimeter and contents
b Vapor pressure in the calorimeter
c Mass of fluid contents of the calorimeter
d Energy added to the system as electric power, converted to heat, and the small heat-leak correction.

Three special types of experiments are made. In the ideal case of perfect manipulation and control of experimental conditions these effect the following three processes:

1 Heating with fixed amount of contents. (Heat-capacity determinations)
2 Isothermal expansion by adding heat, evaporating water, and withdrawing saturated steam. (Latent-heat determinations)
3 Isothermal expansion by adding heat, evaporating water, and withdrawing saturated liquid. (Determination of complementary term for the first two processes.)

From the results of these experiments the heat content of saturated liquid, heat of vaporization, and heat content of saturated vapor are directly derived. In this brief report it is possible to give only a general description of the apparatus, and to touch on only a few of the problems encountered so far.

Fig. 1 shows sectional views of various parts assembled as a whole in approximately actual position and proportion. The calorimeter shell, of special heat- and corrosion-resisting steel, contains besides the water sample an electric heating element for adding measured energy, a system of radial silver plates for diffusing heat, and a system of baffles for intercepting any drops of liquid in a stream of vapor being withdrawn. Attached to the ends of this shell are tubes, one for suspending the shell and for conducting vapor, the other for conducting liquid. This shell is made in two parts held together on a thin silver gasket by a right- and left-threaded band set up by a powerful wrench. This shell, the vital organ of the instrument, holds the water sample whose thermal behavior is to be observed.

The heat-diffusing system consists of thirty plates of sheet silver $^1/_2$ mm (0.02 in.) thick, shaped to conform to the shell profile and held radially in two slotted hubs so as to penetrate the entire space within the shell with a good heat conductor, and thus promote temperature equalization in the calorimeter.

The electric heater consists of 10 ohms of chromel wire 0.2 mm (0.005 in.) in diameter, wound in helical form, 0.6 mm (0.015 in.) diameter, and embedded in magnesia for insulation. This insulated resistor is sheathed in a platinum tube drawn down tightly on the magnesia to an outside diameter of 2 mm. This sheathed resistor is then bent into the form of a helical coil 12 mm in diameter, the resistor taking up about two turns. The leads are of gold wire. The source of heat is purposely concentrated to cause active boiling and thus induce circulation of the water.

The baffle system includes three conical sheets of silver-wire gauze, $^1/_{100}$ in. mesh, with openings for steam staggered so as to prevent direct passage of water drops.

For protection from adventitious sources of heat the calorimeter shell hangs within a double-walled enclosure formed by two coaxial cylindrical silver shells with flat ends, the inner one 6.3 mm (0.25 in.) thick and the outer one 3.2 mm (0.125 in.) thick, which we shall call the "envelope" and "guard," respectively. The outer surface of each of these shells is covered with an electric heating element, distributed with respect to area. Subdivision of the resistors into sections provides a means for compensating local inequalities of external heat loss. Electric energy supplied to the guard furnishes the heat lost to the surroundings plus that required to heat the guard. The temperature of this guard may be automatically controlled at any desired value by a sensitive thermoregulator employing a platinum-resistance thermometer. By proper adjustment of the temperature of the guard and also regulation of the electric power supplied to the envelope, the surface temperature of the latter can be kept so nearly equivalent to that of the calorimeter that the heat-leak correction for any single experiment is usually found to be negligible. For indicating these surface temperatures, the calorimeter shell and the envelope shell each bear the principal junctions of five thermoelements, so distributed as to represent approximately equivalent zones. These thermoelements may be used either in series combination for indicating average temperatures or independently for indicating local temperatures. Eleven other thermoelements are available either for temperature surveys or else to guide in operation. Each of the two outlet tubes from the calorimeter shell bears an electric heater and thermoelement for the purpose of controlling the tube temperatures so as to avoid fortuitous heat leaks by these paths.

Temperatures are referred to the international temperature scale by use of two platinum-resistance thermometers installed in a silver block which is designed to serve as an isothermal union for thermoelement reference junctions and the resistance thermometers. For determining the temperature of the calorimeter and contents when in equilibrium, the small differences between this reference block and the calorimeter shell are measured by the five thermoelements connected in series. Each of the twenty-one thermoelements has one principal junction of chromel-copel wires, and two reference junctions formed by the union of these alloys with the gold leads as described in previous reports.[9,10] These thermoelements each

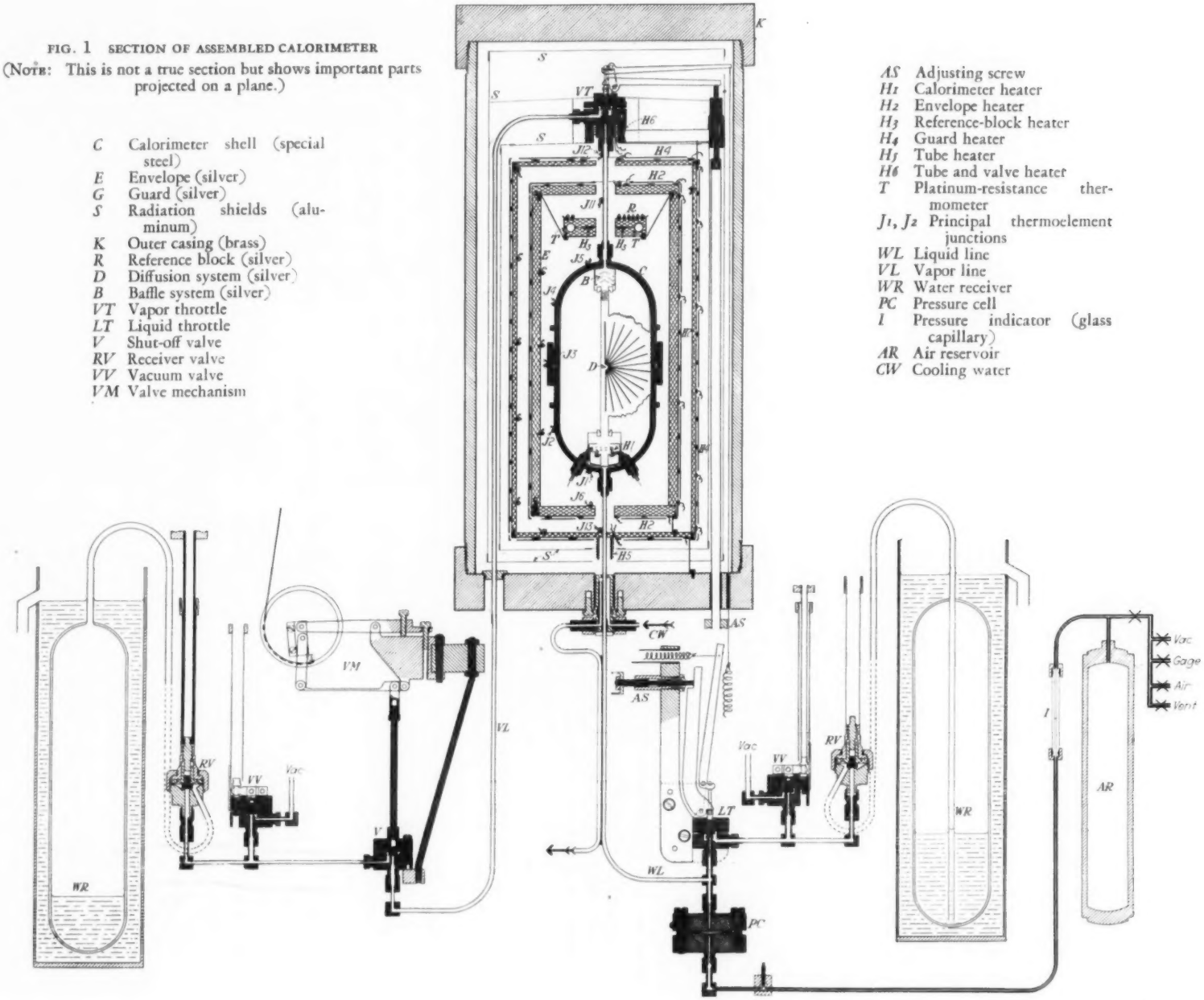
[10] Trans. A.S.M.E. (1930), papers FSP-52-28 and FSP-52-29.
[11] *Journal of Research*, Bureau of Standards, vol. 4, no. 5, p. 609, and vol. 5, no. 2, p. 411.

FIG. 1 SECTION OF ASSEMBLED CALORIMETER

(NOTE: This is not a true section but shows important parts projected on a plane.)

C Calorimeter shell (special steel)
E Envelope (silver)
G Guard (silver)
S Radiation shields (aluminum)
K Outer casing (brass)
R Reference block (silver)
D Diffusion system (silver)
B Baffle system (silver)
VT Vapor throttle
LT Liquid throttle
V Shut-off valve
RV Receiver valve
VV Vacuum valve
VM Valve mechanism

AS Adjusting screw
H_1 Calorimeter heater
H_2 Envelope heater
H_3 Reference-block heater
H_4 Guard heater
H_5 Tube heater
H_6 Tube and valve heater
T Platinum-resistance thermometer
J_1, J_2 Principal thermoelement junctions
WL Liquid line
VL Vapor line
WR Water receiver
PC Pressure cell
l Pressure indicator (glass capillary)
AR Air reservoir
CW Cooling water



give a thermoelectric power of about 80 microvolts per degree at 300 C.

In the space outside the guard, two shields or interceptors made of sheet aluminum 0.05 mm (0.002 in.) thick are so placed as to impede the transfer of heat by both radiation and convection. These shields take the place of lagging material for thermal insulation. The whole is enclosed in a heavy brass casing which serves as a cover and protection in case of an explosive failure.

The valves used to handle the water and steam are extremely vital parts, because the operator's ability to keep control of the experimental conditions and also to account accurately for the amount of water, depends on the nicety with which the valves may be either adjusted for throttling or else closed entirely. No effort was spared in the design and workmanship of these valves to make them operate as perfectly as possible. In all of them a flexible silver diaphragm is used in place of the usual packing to seal against the atmosphere and permit motion of the stem. Two throttle valves are used to control flow either of vapor or liquid from the calorimeter. While throttling from the steam pressure down to the receiver pressure these valves are required to control the flow so that the constant energy input is just compensated by the water evaporated, and a steady state maintained. The material of these valves is, for the most part, stainless steel.

The aperture in the flat valve seat is about 0.35 mm (0.014 in.) in diameter and is closed by contact with the stem end.

The end of the stem is formed by an inlaid disk of a metal which is softer than the seat to favor tight closure. The disk is renewable to allow for replacement on account of erosion. Silver and platinum have both been used for this part, which is subjected to such severe and exacting service. The stem has an axial travel of about 0.1 mm which is accommodated by the flexibility of the silver diaphragm. For fine adjustment of the valve setting the stem is moved by a lever carried on a knife-edge fulcrum and driven by a slow-motion screw operated by hand, giving a large reduction. A second lever, actuated by hand adjustment of a sensitive spring, takes up backlash and also effects a still finer gradual valve adjustment by utilizing the elastic deformation of the valve mechanism.

Three automatic shut-off valves are in the branched line which leads from the vapor throttle and distributes the low-pressure vapor as desired to either of three receivers suitable for weighing. These valves are similar in operation to those previously used on the low-pressure steam calorimeter but are placed outside the heated space for accessibility. The automatic mechanism allows the vapor flow to be shifted instantaneously from one receiver to another by the time signal from the standard clock, without disturbance of the steady state of flow of steam from the calorimeter.

In addition to provision for observing temperature, means have been provided for observing the pressure in the calorimeter. This will permit the energy measurements to be referred to pressure as well as to temperature, furnish an additional check on the vapor pressure-temperature relation, and allow pressure to be used as the control index in evaporation experiments. A branch from the liquid line leads to a cell with a sensitive thin elastic diaphragm, which transmits pressure, while motion of water is restricted to the minute displacement allowed by travel of the diaphragm in the cell. Beyond the diaphragm the connection is filled with water as far as a meniscus in a glass capillary tube in the pressure line. A controlled air pressure is balanced against the transmitting water pressure by observing the position of the meniscus in the sensitive capillary indicator. This vapor-pressure indicator responds within a narrow range to thermal changes in the condition of the evaporating surface, and in an evaporation experiment is a sensitive and reliable guide for controlling the flow by means of the throttle previously described. On account of its virtually instantaneous response, this indicator, together with the sensitive throttle valve, provides a nicety of control of the evaporation process which approaches the ideal. In tests at 250 C it was found that a motion of 1 mm of the indicator corresponded to about 0.003 C, and that the evaporation temperature could be kept within this limit without difficulty. The sensitivity of course depends upon the temperature, characteristics of the diaphragm, volume of balancing air pressure, and the size of capillary. By use of the deadweight piston gage to observe the air pressure when it is balanced against the steam pressure, it will be possible to determine the saturation vapor pressure in the calorimeter at any stationary temperature.

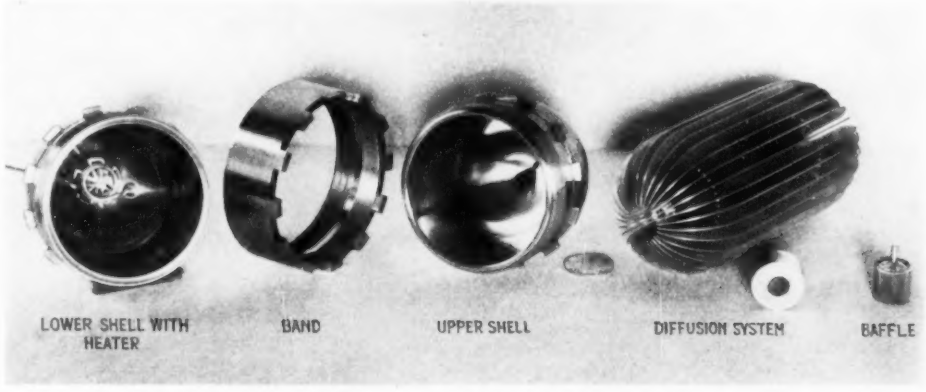


FIG. 2 UNASSEMBLED CALORIMETER SHELL WITH ACCESSORY PARTS
(One-third actual size.)

Views are shown of the unassembled calorimeter shell with the various parts which pertain to it, and of the silver enveloping shells.

Some of the features of the heating and heat-distributing arrangements in this new calorimeter have been changed radically from the instrument previously used, but with the same main objects in view. These principal objects are concerned with the elimination of fortuitous conditions and influences which would impair the accuracy in accounting for the amount, state, and energy of the water whose behavior is being observed.

For distributing energy the new calorimeter depends on induced circulation supplemented by the thermal diffusivity of the system of silver plates, in the place of vigorous circulation of the water sample by a mechanically driven pump. The dissipation of electric energy into heat is concentrated into

small compass to promote active boiling, induce circulation, and avoid accumulation of energy stored as superheat. Spray is intercepted by a simple arrangement of baffles. In the old calorimeter a relatively large heater surface located in the vapor space was continually bathed with a thin film of water to promote quiet evaporation and thus avoid wet steam. Experience with this refinement and comparison of the results with others have indicated that the danger of wet steam in evaporation measurements has probably been overestimated in comparison with other possible errors, and that errors from this cause may be avoided by the choice of appropriate rates of evaporation.

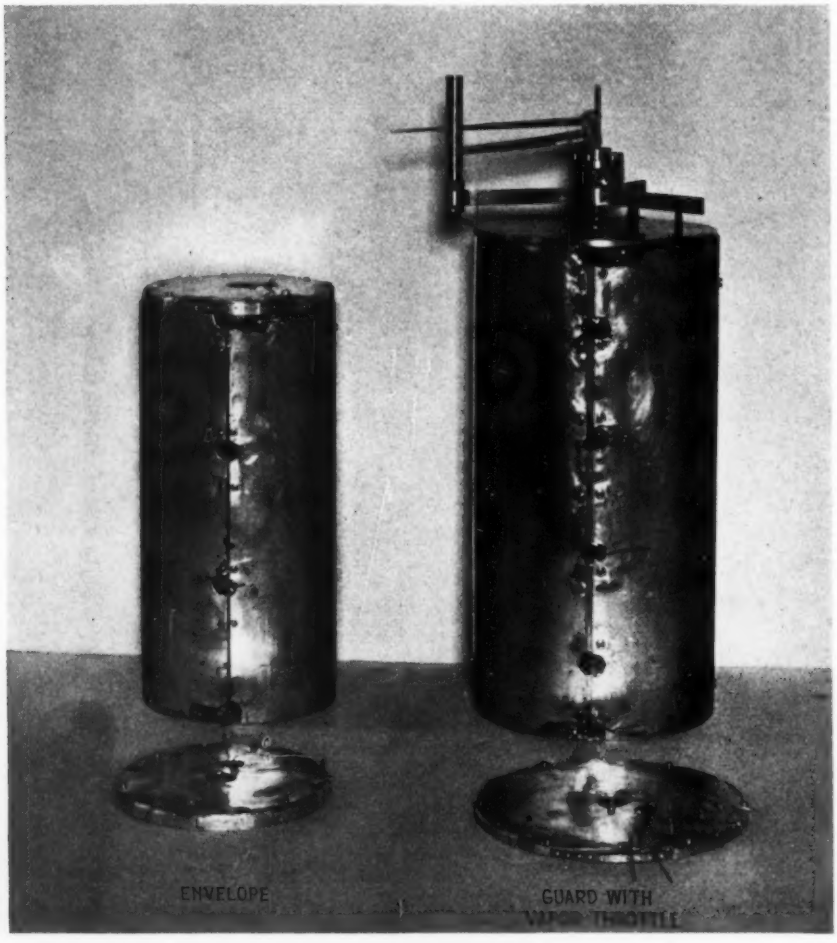


FIG. 3 SILVER ENVELOPE SHELLS
(One-quarter actual size.)

Omission of a calorimeter circulating pump has avoided several difficulties in operation and has also permitted the excess heat capacity to be reduced. With adequate strength for more than double the pressure and with space for the same net heat capacity of useful water sample, the tare or useless heat capacity is less than half that of the old calorimeter with pump. These gains are accompanied by some loss of uniformity in temperature of the calorimeter surface while heating up, due to the slower diffusion of heat.

The double envelope of two silver shells, each with a distributed electric heater, takes the place of an enveloping shell bathed with a circulating stream of oil. This avoids the capricious behavior of the oil at high temperature and provides even better thermal isolation of the calorimeter than the old arrangement. The improved accessibility of inner parts makes it easier to trace and repair such faults as breaks or leaks in electric circuits, fluid leaks, or damage to valves.

The considerations in determining the exact configuration and proportions of the internal organs of the calorimeter have been the conflicting requirements of the three types of experiment which are to be carried out. The result is a compromise between some of the characteristics which would be preferable for each of the three single types of experiment.

What can be accomplished with this new equipment is yet to be determined. The immediate aim of the new experimental program will be the completion of the direct measurement of the heat content of water and steam at the fixed points of the international skeleton table. Another object will be to measure vapor pressure in the regions where discrepancies have been noted between other observers. Still another purpose will be to establish the saturation limit of heat content as a continuous formulation representing the results of direct reliable calorimetric measurements—in other words, to provide the skeleton table of heat content with a complete backbone.

The present stage of the work is exploratory, to develop the technique of operation and to discover at an early date the faults as well as the virtues of the instrument.

Preliminary observations have been successfully made with the new calorimeter at 250, 270, 325, and 350 C. At the lower temperatures where the results could be checked against observations made with the earlier apparatus, the agreement is satisfactory. As far as tested, the new apparatus performs according to expectations. This does not mean without a hitch. Several minor faults in construction have been found and remedied, and more may be anticipated, but in general each part has functioned satisfactorily. How far up in the scale of temperature and pressure this performance will be reliable is a question of interest. It can be said at this time that the outlook is favorable and prospects are excellent for securing additional interesting and useful data in the unexplored portion of the saturation region of steam.

WORK AT MASSACHUSETTS INSTITUTE OF TECHNOLOGY—I[1]

By L. B. SMITH[2] and F. G. KEYES[3]

DURING the past year we have made a large number of *p-v-t* measurements on superheated steam. These measurements cover a range of volumes from 140 to 5 cubic centimeters per gram, and of pressures from about 14 atmospheres up to about 360 atmospheres. The upper limit of temperature in most cases was 460 C, though some of the larger specific volumes were only carried up to 330 C. This body of new data covers the entire range of superheat measurements undertaken as our part of the steam-research program.

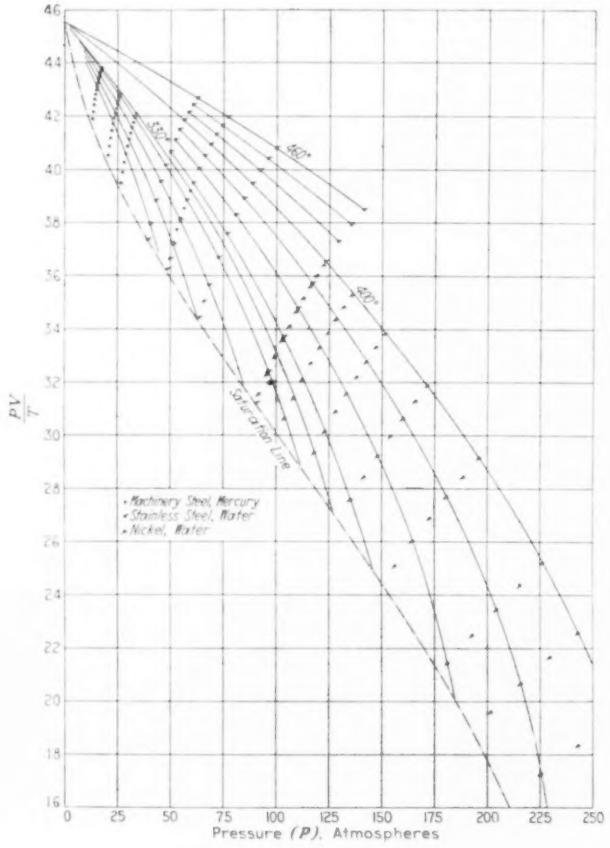


FIG. 1 RESULTS OF M.I.T. MEASUREMENTS ON SUPERHEATED STEAM

(Reprinted from MECHANICAL ENGINEERING, February, 1930, p. 137)

All this new work has been carried out in containers of stainless steel and has been entirely free from those difficulties and limitations which have been discussed at length in previous reports. The measurements fall naturally into three groups: (1) those at larger specific volumes, made in a spherical stainless-steel bomb with mercury as the confining liquid; (2) those at intermediate volumes, made in the same bomb but with water as the confining fluid; and (3) those at the smaller specific volumes, made in a new cylindrical stainless-steel bomb especially designed for high pressures. In this last

TABLE 1 SUPERHEATED-STEAM MEASUREMENTS

(Stainless-steel bomb S_3—confining with mercury.)

Temp, C	Specific volumes, cc per gram: 39.50	40.00	75.00	100.00	140.00
	Pressures in atmospheres				
196.0	....	....	....	....	13.890
197.0	....	....	....	....	13.949
198.0	....	....	....	....	13.995
199.0	....	....	....	....	14.032
200.0	....	....	....	....	14.066
210.0	....	....	....	....	14.471
212.5	....	....	....	19.605	....
220.0	....	....	....	20.072	14.863
227.5	....	....	26.220	....	....
230.0	....	....	26.464	20.650	15.244
240.0	....	....	27.284	21.202	15.619
250.0	....	....	28.062	21.754	16.005
260.0	....	....	28.834	22.282	16.357
264.0	49.135	....	....	....	....
270.0	50.293	....	29.571	22.809	16.736
280.0	51.978	....	30.324	23.340	17.078
290.0	53.604	....	31.033	23.847	17.438
300.0	55.197	....	31.745	24.361	17.792
310.0	56.712	56.159	32.453	24.864	18.136
320.0	58.227	57.604	33.131	25.374	18.492
330.0	59.683	59.067	33.834	25.874	18.829
Extrapolation to saturation					
t_s (deg C)	263.61	....	227.17	211.97	195.11
p_s (atm)	49.056	....	26.188	19.571	13.832

TABLE 2 SUPERHEATED-STEAM MEASUREMENTS

(Stainless-steel bomb S_3)

Temp, C	Specific volumes, cc per gram: 20.00	30.00	40.00	50.00
	Pressures in atmospheres			
251.0	....	....	....	39.365
260.0	....	....	....	40.568
264.0	....	....	48.794	....
265.0	....	....	48.967	....
270.0	....	....	49.825	....
280.0	....	....	51.480	43.063
281.0	....	63.692	....	....
290.0	....	65.882	....	....
300.0	....	68.179	54.675	45.456
305.0	90.550	....	....	....
306.0	91.088	....	....	....
320.0	96.243	72.568	57.677	47.723
340.0	103.592	76.795	60.610	49.955
360.0	110.438	80.852	63.459	52.157
380.0	117.022	84.794	66.239	54.276
400.0	123.362	88.625	68.974	56.392
420.0	129.546	92.384	71.639	58.468
440.0	135.593	96.094	74.276	60.519
460.0	141.502	99.729	76.901	62.571
Extrapolation to saturation				
t_s (deg C)	304.66	280.17	263.07	250.02
p_s (atm)	90.507	63.476	48.633	39.227

[1] Contribution No. 281 from the Research Laboratory of Physical Chemistry, Massachusetts Institute of Technology, Cambridge, Mass.

[2] Assistant Professor of Physico-Chemical Research, Massachusetts Institute of Technology.

[3] Director of Research Laboratory of Physical Chemistry, Massachusetts Institute of Technology.

group, also, water was the confining fluid. These three sets of measurements overlap one another and exhibit a degree of consistency hitherto lacking.

The new data are set forth in Tables 1, 2, and 3.

Fig. 1, published in our report of last year, indicates rather clearly the scope of our work at that time. A certain lack of consistency is especially noticeable between the measurements at intermediate volumes and those at small volumes. Fig. 2 is made up entirely from the new data, though to avoid confusion not all the points are shown. A general improvement in consistency is at once apparent, and it will also be noted that the smaller volumes have been extended to higher temperatures and pressures.

The improvement in accuracy has resulted in part from the use of stainless-steel containers and in part from an improvement in experimental technique. It will be recalled that, in using water to confine the steam, the limit of accuracy was dependent on the precision with which the distribution of water between the liquid phase and the vapor phase could be determined. By using a smaller-bore connecting capillary tube and adding a concentrated heating element to the tube just where it enters the high-temperature bath and immediately below the cooling element, we are able to sharply fix the point of transition at which the water changes from the liquid phase to the vapor phase.

As the final experimental stage in the M.I.T. program, it is our intention to repeat and perhaps extend our previous measurements of the compressibility of liquid water.

TABLE 3 SUPERHEATED-STEAM MEASUREMENTS

(Stainless-steel bomb C_4)

Temp, C	Specific volumes, cc per gram: 5.00	6.25	7.50	10.00	12.50	15.00	17.50	20.00
	Pressures in atmospheres							
305.5	.....	.....	.....	.....	.....	.....	.....	90.711
310.0	.....	.....	.....	.....	.....	.....	.....	92.527
313.0	.....	.....	.....	.....	.....	.....	101.226	.....
320.0	.....	.....	.....	.....	.....	.....	104.224	96.284
322.0	.....	.....	.....	.....	.....	113.897	.....	.....
330.0	.....	.....	.....	.....	.....	118.342	108.625	99.949
332.5	.....	.....	.....	.....	130.515	.....	.....	.....
340.0	.....	.....	.....	.....	135.576	123.651	112.920	103.527
344.5	.....	.....	.....	151.742	.....	.....	.....	.....
350.0	.....	.....	.....	156.513	142.130	128.761	117.084	107.039
357.5	.....	.....	178.295	.....	.....	.....	.....	.....
360.0	.....	.....	181.280	165.038	148.477	133.777	121.162	110.459
364.5	.....	194.001	.....	.....	.....	.....	.....	.....
370.0	.....	201.829	193.110	173.280	154.648	.....	.....	.....
371.5	210.657	.....	.....	.....	.....	.....	.....	.....
380.0	225.683	216.003	204.560	181.276	160.420	143.367	129.001	117.035
400.0	260.558	243.371	226.684	196.790	172.331	152.578	136.584	123.461
420.0	294.385	269.583	247.900	211.648	183.499	161.404	143.844	129.554
440.0	327.638	295.361	268.553	226.043	194.347	169.992	150.867	135.513
460.0	359.955	320.251	288.526	240.026	204.865	178.366	157.791	141.398
	Extrapolation to saturation							
t_s (deg C)	370.34	363.75	356.74	343.65	331.83	321.44	312.60	304.58
p_s (atm)	208.715	192.944	177.387	151.070	130.091	113.621	100.937	90.407

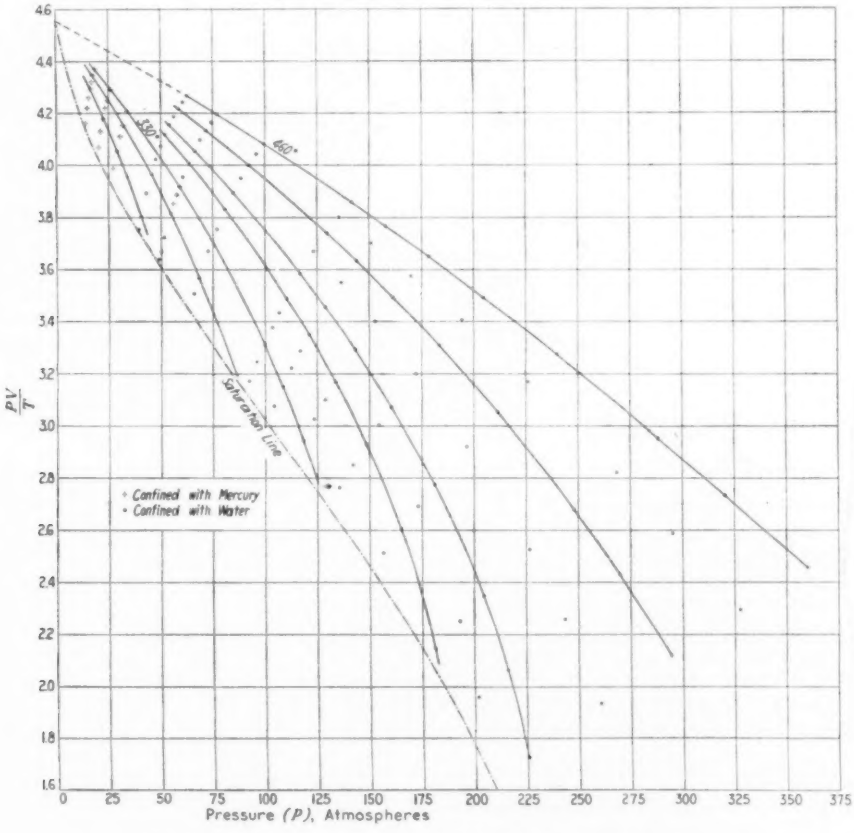


FIG. 2 RESULTS OF NEW M.I.T. MEASUREMENTS ON SUPERHEATED STEAM

WORK AT MASSACHUSETTS INSTITUTE OF TECHNOLOGY—II[1]

By F. G. KEYES[2] AND L. B. SMITH[3]

SINCE our last meeting of a year ago considerable effort has been expended in the attempt to refine and perfect the correlation of the pressure-volume-temperature data taken at the Massachusetts Institute of Technology. There are two parts to such a problem, the first of which concerns the examination of the latter data for the purpose of gaining information regarding the consistency of the data to be used in deciding what measurements require repetition or confirmation. The second part relates to comparisons of the p-v-T data, through thermodynamic relationships of derived quantities which may be compared with similar quantities directly measured by our colleagues in the cooperative steam investigation. Some comparisons of this sort were exhibited last year,[4] and a somewhat encouraging indication of thermodynamic consistency was disclosed as regards heats of evaporation computed by the Clapeyron relation

$$T \frac{dp}{dt} (v_1 - v_2) = \lambda$$

and the measured quantities obtained by Osborne, Stimson, and Fiock.[5] Also, the pressure-temperature relation for the saturated vapor resulting from the M.I.T. work was shown to be in good agreement with the results obtained at the Reichsanstalt. Considerable data were also published pertaining to saturation liquid volumes from 100 deg to the critical temperature, along with values for the p-v-T properties of liquid water under pressures to 300 atm. Certain new p-v-T values for the vapor phase were given by Prof. L. B. Smith for which the temperature range had been extended to 460 C.

During the past year the continuation of the effort to correlate our data has brought to light certain interesting discrepancies which may possibly be regarded as confirming possibilities hitherto entertained with reference to the temperature scale. In the main, therefore, this year's report will center on a brief discussion of this matter for the reason that if our surmises are correct we shall be concerned with a very fundamental question, the complete elucidation of which may require considerable time.

ABSOLUTE-TEMPERATURE SCALE IN USE FOR THE STEAM RESEARCH

Evidently the temperature scale for use in all thermodynamical formulas is the absolute or Kelvin scale, defined through the relation $Q_1/T_1 = Q_2/T_2$ where Q_1, Q_2, T_1, T_2 are the heat quantities and temperatures pertaining to a reversible Carnot cycle. An ideal or "perfect" gas defined as one for which $pv = RT$ and whose internal energy is independent of the pressure and a function of temperature only would therefore, if it existed, constitute a thermometric substance making it possible and convenient to measure absolute or thermodynamic temperatures. Experiment indicates that an actual gas, such as, for example, hydrogen, helium, or nitrogen, does conform to the definition of an ideal gas as the pressure is indefinitely reduced to zero. Thus an actual gas may be used to establish and reproduce the thermodynamic scale of temperature, provided the measurements are carried out in such a way that the experimental data may be extrapolated to give values corresponding to the zero-pressure condition.

The attempts to carry out this procedure accurately have been numerous. Such measurements in gas thermometry are, however, attended with very great difficulties, and much effort must yet be expended before a really satisfactory knowledge of the relation of the thermodynamic temperature to our secondary standards, such as the platinum-resistance thermometer, is obtained. It was with a full knowledge of the incomplete character of gas-thermometry information that the wise decision was taken by the Steam Committee to adopt the temperature scale of the platinum-resistance thermometer whose resistances at various temperatures were to be related to the adopted scale by the Callendar formula

$$t - pt = \delta \left(\frac{t}{100} - 1 \right) \frac{t}{100}$$

where pt denotes "platinum temperature," defined as $pt = 100 \dfrac{R - R_0}{R_{100} - R_0}$, R, R_0, and R_{100} referring to the thermometer's electrical resistances at t, 0, and 100 C. The constant δ is determinable when the thermodynamic temperature of a fixed point other than 0 and 100 is known.

[1] Contribution No. 282 from the Research Laboratory of Physical Chemistry, Massachusetts Institute of Technology, Cambridge, Mass.

[2] Director of Research Laboratory of Physical Chemistry, Massachusetts Institute of Technology.

[3] Assistant Professor of Physico-Chemical Research, Massachusetts Institute of Technology.

[4] MECHANICAL ENGINEERING, vol. 53 (1931), p. 132.

[5] At the time the comparisons were made (spring, 1930) the product of the Clapeyron-equation quantities T, dp/dt, and $(v_1 - v_2)$ [T in degrees Kelvin (273.1 + t), dp/dt in international atmospheres per degree, and $(v_1 - v_2)$ in cubic centimeters per gram] was multiplied by 0.024206 to convert to "calories" as set forth in the article containing the tables of comparison. The tables had been prepared as "Provisional and Confidential" information for the Berlin conference held in the summer of 1930, where it was hoped some discussion (if not a decision) would be entered into regarding the conversion factor to pass from joules to International Calories. We (K. and S.) have now adopted (Tech. News Bull. Bur. of Stand., April, 1930) in our correlations the relation: 1 international joule = 1.0004 mechanical joules. The conversion factor thus becomes 0.024196, one part in 2500 smaller than 0.024206. At the time of the spring, 1930, correlations the interest in whether the conversion factor was the one or the other of these figures was of no serious import since we lacked confidence that our values computed by the Clapeyron relation could be within better than one part per thousand of the precise measured values of Osborne, Stimson, and Fiock.

One further point is of interest. The actual measurements of the latter extended from 100 C to 270 C, but an equation which represented the measurements accurately in the experimental range had been presented by Osborne, Stimson, and Fiock. In order to extend our comparisons of the heats computed from the Clapeyron equation we used the O., S., and F. equation to compute "extrapolated" heats of evaporation. It is to be observed, however, that such extrapolated values have no guaranteed merit, no matter how precise the measurements upon which the empirical equation is based. It will be clear, therefore, that, while interesting, no particular significance should be attached to the comparisons presented at temperatures above 270 C, or, as a matter of fact, to extrapolated values computed below 100 C, although now experimental determinations are available to 50 C.

Using the 1912 edition of "The Measurement of High Temperatures," by G. K. Burgess and H. Le Chatelier (p. 199), the following comparison table has been formed between temperatures obtained from the gas and resistance scales of temperature:

Mean of gas-scale temperature	Mean of platinum-scale temperature
320.85	320.85
418.60	419.40
629.90	630.40
657.50	658.00
960.75	961.40

The authors of this work remark: "These results confirm the view of the sufficiency of the Callendar difference formula for the most accurate work up to the upper limit of the safe use of the platinum-resistance thermometer." One observes in the table differences which today appear huge compared with the precision of the temperature measurements (0.01 deg) being striven for in the steam investigation.

The fixed point other than the defined ones, 0 deg and 100 deg, was the N.B.P. of sulphur assumed to be 444.6. On page 434 of the treatise by Burgess and Le Chatelier the gas-thermometric determinations by different workers of the boiling point of sulphur show a maximum difference of 0.3 C for the constant-volume gas thermometer. Clearly the evidence that the platinum-resistance thermometer will reproduce the absolute-temperature scale between 100 C and 444.6 C to within 0.01 C is not convincing.

GAS-THERMOMETRY INVESTIGATIONS AT M.I.T.

The probability that the steam investigation would provide values for the properties of water far exceeding in accuracy similar values ever before obtained for any substance, induced the decision eight years ago to drop temporarily the investigation of the gas scale already in progress in the range below zero degrees and turn to the gas scale above zero. Dr. James A. Beattie took over the investigation and set out to devise, secure, and assemble the best equipment obtainable for carrying out a program of investigation designed to include a study of the platinum-resistance thermometer, the gas thermometer employing several gases, and the intercomparisons of the platinum and gas scales of temperature.

Progress has been slow since much of the special equipment had to be made up abroad and many sources of error had to be carefully investigated. Nevertheless something over a year and a half ago Dr. David D. Jacobus completed a series of comparisons between the gas scales of helium and hydrogen and the platinum-resistance scale, as well as determinations of the ice-point temperature on the thermodynamic scale. This fall Dr. John M. Gaines has repeated Dr. Jacobus' work, employing certain improvements suggested by Dr. Jacobus' and his own experience. During the late fall further extensive improvements have been made in the apparatus, and the comparisons above 100 deg are about to be started.

RESULTS THUS FAR ATTAINED

At this time it would be premature to give any experimental data, but qualitatively the nature of certain results may be indicated. First, we mention the value for the ice point. The value adopted by the Steam Committee was 273.1, or the value to be found in the International Critical Tables. One of the authors over ten years ago adduced evidence indicating that this value was too low, thereby confirming the conclusion reached, in a different way, by Dr. Buckingham of the Bureau of Standards in 1907. Moreover the Reichsanstalt workers have shown through new investigations conducted in the past ten years that 273.1 is too low. The present work of Beattie and Jacobus and Beattie and Gaines, thus far unpublished, also shows that it is too low. The true value may not be far from 273.16.

It might be expected that the maximum discrepancy, if any, between the thermodynamic temperature and the platinum-resistance thermometer scale with N.B.P. of sulphur taken as 444.6 would occur at about 50 C in the 0–100-deg interval. At present this seems to be the case, and the thermodynamic temperature, centigrade, is less than the platinum-resistance scale by an amount hardly small enough to be neglected.

It is already well known that the Callendar difference formula fails to give correctly the difference between the gas scale and the platinum scale at —180 deg by a very significant amount. The results which it is hoped will be secured in the next year or two will give positive and quantitative information regarding the differences between the present accepted platinum-resistance scale and the gas thermometer above zero. But however satisfactory the results may appear when obtained, it is scarcely likely that they will be accepted by appropriate and generally recognized authorities until confirmed by independent work carried out elsewhere. This is as it should be, for in matters as fundamental as the question of establishing the relation between the thermodynamic scales and the accepted secondary scale of the platinum-resistance thermometer, extensive confirmation is necessary—otherwise confusion results. It is to be hoped, therefore, that interest in the matter will prompt similar investigations to be undertaken elsewhere in the near future.

OTHER CURRENT STEAM RESEARCH

By HARVEY N. DAVIS[1]

DR. DAVIS reported on current work in other laboratories. In particular, he mentioned two experimental papers, one recently published,[2] and one promised for the near future.

The first is a paper by Trautz and Steyer, of Heidelberg, on the specific volume and total heat of liquid water at high pressures and temperatures. Their specific-volume method is like that of Keyes and Smith in that they determine the amount of liquid that will fill a container of known volume at a given pressure and temperature. The deviations of their values from those of Keyes and Smith, as represented by

[1] President, Stevens Institute of Technology, Hoboken, N. J. Vice-President A.S.M.E.

[2] Trautz and Steyer, "Die Zustandsgrössen des Wassers im Bereich von 10° bis 500° und vom Sättigungsdruck bis 300 at.," *Forschung auf dem Gebiete des Ingenieurwesens*, vol. 2, no. 2, February, 1931, pp. 45–52.

Keenan's compressed-liquid table of 1931,[3] are shown graphically in Fig. 1. It will be noticed that these deviations become large only in the region near saturation above 300 C corresponding to saturation pressures above 1250 lb per sq in. This systematic deviation is discussed at some length in a paper by Jakob, mentioned below, with the result that Jakob apparently prefers the values of Keyes and Smith.

The good agreement between this work and that of Keyes

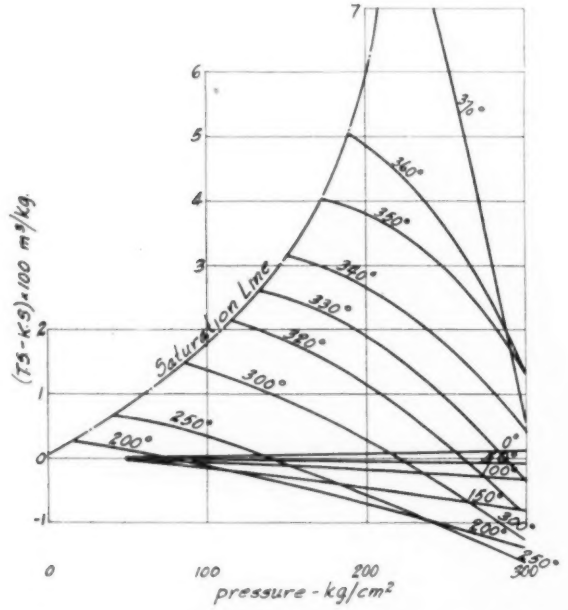


FIG. 1 DIFFERENCES BETWEEN VOLUME DATA ON COMPRESSED LIQUID WATER

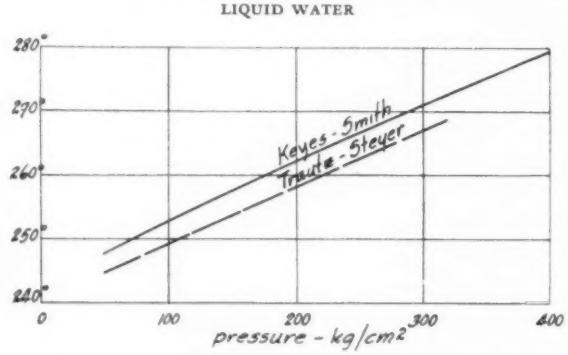


FIG. 2 JOULE-THOMSON-EFFECT INVERSION LINE
(Along this line constant-temperature lines and constant-total-heat lines are tangent to each other.)

and Smith near 250 C is shown by the Joule-Thomson inversion-point loci of Fig. 2.

Their total-heat or enthalpy method is apparently open to criticism on the ground of sensitiveness to error in the computation of heat-leak corrections and otherwise, and, at least at 200 kg per sq cm, gives values for the superheated vapor a little above those which the Berlin Conference led us to expect.

A second experimental paper of importance, this time on the specific heat of superheated steam up to 450 C and 200 kg per sq cm, by Knoblauch and Koch, of Munich, is promised for publication in the January, 1932, issue of the journal *Forschung auf dem Gebiete des Ingenieurwesens*.

[3] Keenan, "Thermal Properties of Compressed Liquid Water," MECHANICAL ENGINEERING, vol. 52, no. 2, February, 1931, pp. 127–131.

Dr. Davis next mentioned a formulation paper by Hausen,[4] of Munich. The approach is from the specific-heat side. The value of C_{p0} as a function of temperature, approached as a limit as the pressure approaches zero, is, for the first time in such work, determined theoretically by means of the quantum theory. The difference $C_p - C_{p0}$ at constant temperature is then formulated empirically as a function of pressure and temperature by means of an equation involving nine constants. From this equation formulas for specific volume, enthalpy, and entropy are obtained by means of the usual thermodynamic relationships. Two "integration constants" appear in the form of unknown functions of the pressure, which was held constant in the integrations. These were determined by means of the available measured values of v and of h along the saturation line, and the formulation thereby acquires five additional constants, making fourteen constants in all, in addition to the usual R and the critical values of p, v, and T. The resulting formulation is nevertheless not too hard to compute with, and gives values within the tolerances of the Berlin Conference except at three unimportant points.

Finally Dr. Davis mentioned a course of four lectures delivered in May, 1931, before the University of London, by Dr. Max Jakob, of Berlin, on "Steam Research in Europe and in America," which are being published in full in *Engineering*. So far only three instalments[5] have appeared, covering the first two lectures. Of particular interest to Americans is Dr. Jakob's careful discussion on page 145 of the issue for July 31 of the work of Trautz and Steyer mentioned on the preceding page but the lectures as a whole are an admirable critical summary of the whole experimental situation.

The Process of Evaporation

IT MAY be asked how a steam bubble originates in the liquid. If steam is able to exist as a separate phase, a surface of separation is necessary, as, for instance, in a globule, but the liquid offers resistance to the formation of such a curved surface, and the question of surface tension has to be considered. This tension, in the interior of such a small bubble surrounded by the liquid, causes a lower steam pressure than at the same temperature on a plane surface. The laws applicable in this case have been set out by William Thomson (Lord Kelvin). From these it follows (1) that smaller bubbles are unstable compared with larger ones, and (2) that, in equilibrium, the liquid in the neighborhood of a steam bubble must have a higher temperature than the temperature of saturation for a plane surface at the same pressure. Therefore, if, in a liquid, a very great number of small bubbles exist, the liquid, on an average, has a higher temperature than that corresponding to the saturation pressure at a plane surface; in other words, the water is superheated, and this is still more the case the smaller the bubbles, the radius of curvature determining the degree of superheat. From this follows the strange result that in an absolutely pure liquid no vapor bubbles at all could originate, the initial diameter of such bubbles being infinitely small and the superheat infinitely high. Indeed, pure water at atmospheric pressure could be superheated to a high degree without evaporation.—Max Jakob in *Engineering*, Dec. 25, 1931, p. 801.

[4] Hausen, "Eine neue Zustandsgleichung des Wasserdampfes," *Forschung auf dem Gebiete des Ingenieurwesens*, vol. 2, no. 9, September, 1931, pp. 319–326. Abstracted on page 142 of this issue of MECHANICAL ENGINEERING.

[5] *Engineering* (London), vol. 132, July 31, 1931, pp. 143–146; October 23, 1931, pp. 518–521; and October 30, 1931, pp. 550–551. [Since this report was written, the two remaining lectures have been published in the Nov. 27, Dec. 4, Dec. 11, and Dec. 25, 1931, issues of *Engineering*, on pp. 684–686, 707–709, 744–746, and 800–804, respectively.—EDITOR.]

LEAD OLEATE-OIL LUBRICANTS

Experiences Therewith Resulting in Explosions

By C. G. WILLIAMS[1]

IN THE last few years much good work has been done on lubrication by the A.S.M.E. not only in actual testing but in assembling, correlating, and cataloguing much of the flow of information on lubrication that has been compiled by the experimental and chemical forces of our oil companies and in some cases of our automobile companies and other private firms that have done most of our actual experimenting.

In MECHANICAL ENGINEERING for November, 1931, on page 832, appeared an abstract of an article on lead oleate and border-line lubricants. There seems to be one peculiarity in the use of lead oleate, in whatsoever degree of viscosity as a lubricant, and more especially in the lighter grades, that seems in great need of being considered. This is the explosive-gas and frictional fire hazard.

The author's experience with lead oleate began in the late fall of 1928, when experimenting with an extra heavy type of grinder having a 4-in. spindle. Because of vibratory effects, a special bronze bearing was installed (Fig 1). It was seemingly impossible to obtain an oil that would lubricate the bearings when the machine was running with full load. At last a lead oleate compounded with a light grade of motor oil was used (approx. 215 visc. at 100 F). Still later a lead oleate—medium-grade sulphur bearing oil was used (680 visc. at 100 F). Both of these were commercial products. They gave fair results in so far as actual lubrication was concerned, though the lubricant with sulphur oil gave better results than did the other. Finally the bearing was wrecked by an explosion which was thought to have resulted from structural strains combined with cooling strains set up in the casting and which machining could not or did not entirely eliminate.

Another housing was machined and assembled. The same lubricant was used. After running some time, a series of light explosive sounds seemed to be set up in the housing. The handhole plate was removed, and in the darkness of the cavity (the work was being done at night) could be seen a glow that flitted to and fro at the end of the bearing. This glow seemed to move always in the direction of the movement of the spindle. Nothing could be detected when a light was projected on the bearing. There were several spurts of flame, some of which were seemingly 6 in. long, accompanied by an explosive sound. Later tests with this same bearing, but in the daytime, showed sharp spurts of flame about an inch long accompanied by a crackle as of an electric spark. When at its highest intensity, a light-bluish gas emerged from the handhole opening.

Subsequent tests with larger spindles confirmed the first ones, and in a test with a 5-in. spindle, using roller bearings, a handhole plate was blown off, breaking two $^5/_{16}$-in. fillister-head screws. The cavity was found to be full of a bluish gas or smoke. The gasket was ruptured in several places, and the inner edge at one end was burned as with an intense heat. Later, $5^1/_2$- and 6-in. spindles were tried out but no disastrous explosions resulted, though in one case, with the 6-in. spindle, the handhole plate, which was not fastened in place, was tossed up twice to a height of about 6 in., and falling back, slid to the floor. An installation of two types of roller bearings on the 6-in. spindle gave explosions that blew off the handhole plates. An examination made just before the explosion showed no evidence of gas. After the explosion, however, the cavity was filled with a bluish gas having an odor somewhat resembling that of ammonia.

In all these cases, upon examination there seemed to be a lack of oil or an oily feeling on the bearing after the explosion, but there was a charred fringe of some material along the edge of the bronze bushing, and a pinkish brown color on the bottom of the steel spindle but not on the top. The rollers on the roller bearings seemed singularly devoid of an oily feeling, but were covered with a thin layer of a pinkish or grayish pink substance.

All of these tests brought out varying results as to lubrication. At times the mixture (680 visc. at 100 F) having a very low paraffin-wax content or no sulphur content would be used for quite long periods without any trace of glow in the bearings, when suddenly it would be apparent but unaccompanied by spurts of flame. Again there would be very small spurts of flame and no glow. After the appearance of the glow and its continuance for some time, or of the spurts of flame, the bearing would heat up, whether it were a bronze, roller, or ball bearing.

Where the oil had a sulphur content (680 visc. at 100 F), the period of use before the glow or spurts of flame appeared was longer than for the other types, but in all cases where the glow or the spurts of flame showed—and sometimes there would be spurts of flame of varying lengths, up to 6 in., in the midst of the glow—the glow was brighter, the flame longer and sharper, and the tendency to loud explosions, with disastrous effects to the bearings, more apparent.

Later experiments were carried on with various types of bearings on spindles of from 9 to 14 in. diameter, using hard babbitt, bronze, and two types of roller and ball bearings. The pressures on these bearings ran from 96,400 lb up to 385,360 lb. on two bearings. In all but the 9-in. size the babbitt bearing was eliminated because of the heavy pressures. This bearing was water jacketed, and when lead oleate was used the bearing gave way much more rapidly than was the case when heavy oils (2100 visc. at 100 F) were employed.

In all of these later tests, the fact that the pressures varied or were intermittent in intensity by from 24,100 lb up to 96,340 lb and shifted somewhat from side to side—that is, from right to left or left to right when one stood facing the end of the shaft, though always directionally downward—helped to maintain lubrication, as also did the low surface velocity, approximately 1250 fps, but in all cases excepting that of the 9-in. shaft, lubrication was very poor, so lead oleate compounded oils were tried.

As there was a heavy and continuous flow of water around and through these machines, labyrinths were used on all types of bearings, excepting the babbitt, to keep it out of the bearing. It is thought that this construction helped or was a contributing factor toward the destructive effects of the use of lead oleate lubricant, in that it provided cavities for the

[1] Consulting Mechanical Engineer, Davenport, Iowa. Mem. A.S.M.E.

storage of the gas or explosive generated, and confined it after the explosion.

With a bronze bushing run on a high-strength cast-iron base (the shaft revolving inside the bronze bushing—see Fig. 2) much better results were obtained by the use of a sulphur bearing oil (2100 visc. at 100 F) than with lead oleate lubricants. The lead oleate test was stopped because of the effects of a series of heavy explosions, which though not at first destructive to the machine proper, threw out spurts of flame two feet long, and scattered burning oil for several feet from the bearing, even blowing out and burning the felt used in the labyrinths. Shields or caps were then placed over the end of the shaft to protect the workers and the test was continued, until finally a series of explosions resulted in breaking the caps on top of the bearings.

The nature of the machine required that the housing of the bearing be made in two parts, split on the center line of the shaft. These caps were held in place with four $1^1/_2$-in. studs. After the explosion the studs were found to be bent and stretched, but not broken. The caps were broken across the top and raised up somewhat at the break, so that new caps had to be secured and bored in place before the test could be continued.

The following deductions were made: Wherever heavy masses are given continuous motion, thus generating large frictional resistance, or where high speeds or high linear speeds will be the means of developing equally large frictional resistance, the fluid particles of the lubricant will have a tendency to drain out of the oil-lead oleate compound, seemingly by capillary attraction, leaving only a heavy residue of lead compound to absorb the heat of friction generated.

If the bearing is of a simple form that has no radiating cavities for the storage of the generated gas, and so designed that all the gas generated will escape into the open air from the ends of the bearing, there will be no actual explosive effect, though in the dark an intermittent glow, which may or may not be interlaced with small spurts or tongues of flame, may be seen at the very edge of the bearing, moving from side to side around the bearing in the direction of rotation, somewhat as a will-o-the-wisp, though in the light of day nothing of the sort is visible.

If, however, the bearings are of the compound type, with closed radiating cavities, with labyrinths to exclude water and to retain lubricant, or with caps over the ends of bearings, where gas may be stored and accumulated as generated, there may result a destructive explosion accompanied by such an intense heat as to even consume the paint around any opening through which the flame may emerge.

As the heat of friction increases, a colorless gas, seemingly a component of the oil remaining and the burning lead, will be generated. It may be the result of a cracking process of the oil, or it may be a combined cracking of the oil and likewise a cracking process, a breaking down, of a chemical transformation or reaction in the lead oleate resulting from a combination of frictional heat and mass pressure that generates the gas (if it be a gas), but whatever may be the process, this gas or substance has all of the requisites of a high explosive combined with a flame-producing capacity that together will form a highly destructive hazard.

At first this explosive effect may take the form of many small explosions of the gas or substance, that will carry off or burn out the objectionable fumes without any progressive explosive or fire effect. Again this action may not take place at all until enough of the gas or other substance has been generated to cause an explosion and fire hazard.

As regards the chemical mechanism which might account for the formation of explosive substances where lead oleate is used, nothing better than a guess can be ventured, particularly as, in the first place, we are not dealing here with pure materials, and in the second place, if any explosive material is really formed, its quantity is naturally extremely small. It might therefore be accounted for by the presence of impurities in the lubricant or in the lead oleate mixed therewith. To present a really reliable explanation it would be necessary to trace the exact composition (what is known as a 100 per cent analysis) of every ingredient that goes to form the lead

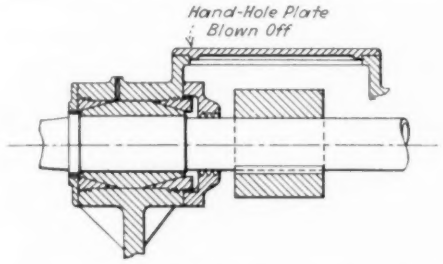


FIG. 1 TYPE OF BRONZE BUSHING USED ON GRINDER
(Spindles 4, $4^1/_2$, 5, $5^1/_2$, and 6 in. in diameter.)

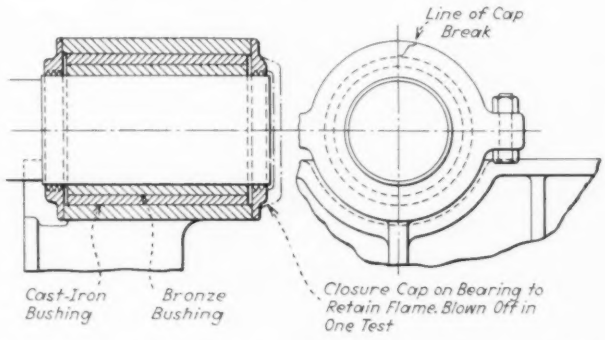


FIG. 2 BEARINGS WITH DOUBLE BUSHINGS ON SPINDLES OF 8 TO 14 IN. DIAMETER

oleate type of lubricant. In so far as the author is aware, this has never been done.

The following, however, may be of interest in this connection, not as an attempt to explain what happens but in the nature of a suggestion for future investigation. Lead salts form a number of explosive substances; for example, lead hyponitrite, $[Pb(NO)_2]$, lead nitrohydroxylamine (PbN_2H_3), lead imide (PbNH), lead azide (PbN_6), and lead trinitride. Moreover, if by any chance hippuric acid is present, it may produce not only explosive lead compounds but also explosive iron compounds. We know comparatively little as to the mechanism of the formation of all of the above compounds, which, incidentally, are not the only explosive compounds derivative of lead. In any event some sources of nitrogen, such as ammonia, must be present to form such compounds and the question is, is there any step in the manufacture of lead oleate itself or of the oil with which it is compounded which would permit us to assume that at least traces of a nitrogen compound are present. Only traces would be necessary as the explosive lead compounds are practically all of the detonating type and are therefore capable of producing wide destruction, even when present in minute quantities.

NOTE: The A.S.M.E. Petroleum Division Committee on Lubrication Engineering will be glad to receive any data or information dealing with the phenomena reported by Mr. Williams.—EDITOR.

MECHANICAL ENGINEERING

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GEORGE A. STETSON, *Editor*

MAX E. R. TOLTZ, engineer and architect, whose death, on January 11, came as a great shock to his friends, was a man whose energy, vigor, and alertness, both physical and mental, were so pronounced that those who knew him found it difficult to believe that he had reached the age of 75. His was a pioneer spirit. Educated in Germany, and coming to the United States in 1882, he spent the first 25 years of his life in the new world helping to build and operate railroads in the Northwest. His interests in professional and civic affairs were abundant. He was one of the organizers and first chairman of the Minnesota Section of the A.S.M.E. and later, manager and vice-president of the Society. Ever grateful to those who had helped him with his education, he established in the A.S.M.E. a fund of $15,000, used for loans to students. The profession has lost a man whose interests transcended his consulting practice and included the world at large.

Engineers and English

ENGINEERS are frequently accused of being unable to express themselves adequately in clear and forceful English. We have frequently commented on this deficiency, but we have also averred that as a class, engineers are no less articulate than is any other group of non-literary professional men. The technical vocabularies of most professions and the special knowledge which these vocabularies were developed to express are handicaps not only to writing but also to understanding what has been written. It must be confessed, therefore, that ignorance of the vocabulary and special knowledge of engineering is as much to blame for the fact that laymen fail to understand what engineers are talking about as is lack of facility in speech or writing. While each science has its Huxley or its Eddington, such men are rare and have unusual attainments. The veils they lift uncover only the most easily descried of mysteries. Only those who spend years of hard study can ever comprehend more fully.

In the simpler forms of daily expression, such as ordinary speech, letter writing, reports, and informal addresses, the engineer faces a difficulty common to others as well, and, if he has been educated in technical and engineering schools, he faces it with less training than do graduates from schools where greater time permits greater attention to literature and expression. This natural handicap is recognized by engineers and educators, and these now jointly propose to do something about it. The S.P.E.E. has recently announced that it will conduct this July at the Ohio State University a summer-school session for those who teach English to engineers.

The engineering student in the past has, in general, been ill served in two important particulars by those who provide his education in English. First, English has seldom, if ever, been properly integrated into the engineer's course of training. Second, not enough consideration has been given to the selection of the best-qualified persons for its teaching. Announcement of the S.P.E.E. summer-school sessions on English leads us to hope that these and other aspects of this important question will be thoroughly discussed. This sincere and practical effort to improve the quality of instruction in English given to engineers comes from the engineering educators themselves, and has the endorsement and assistance of the engineering societies. Engineers individually will do well to encourage the S.P.E.E. and teachers of English to make the most of this important venture.

Interplanetary Transportation

THE problem of interplanetary transportation is now being considered in such a way as to entitle it to a brief analysis by the engineering profession. While it is recognized that the transportation of human beings from the earth to other heavenly bodies is not an immediate possibility, evidence nevertheless indicates that the day may come when it will be attempted.

Fundamentally, there is nothing impossible in sending a missile from the earth, to, let us say, the moon. If a modern gun can throw a projectile to a height of thirty miles, it should be possible to design a gun that could throw one to a height of a hundred miles. The problem, therefore, becomes simply a question of the improvement of certain factors to make it possible to throw a missile beyond the field of gravitational attraction of the earth with the chance of its falling on the surface of the moon.

As a matter of fact, the gun is not necessary. Calculations indicate that even today it should be possible to send a rocket from the earth to the moon. The most serious problem is one of finding the funds necessary to build such a rocket on account of the project's apparent lack of serious utility. A rocket falling on the surface of the moon would give us no useful information as to our satellite or as to rocket flight. To serve these ends it would be necessary to construct a rocket that would carry a man or men inside its shell, which involves the problem of building a rocket that will not only carry a man to the moon but also bring him back. This, however, is a difference of degree rather than of kind. By improving the rocket and its fuel, it can be made to fly both ways; and it should be remembered that less fuel will be required on the return trip.

Analyzing the problem further, however, brings out

some more serious difficulties. For example, we know that it is perfectly possible to use gasoline as a fuel on earth where the ambient temperature is, say, 60 F, but whether it will be possible to use it at absolute zero temperature in interplanetary space is a question. Whether it will be possible to discharge the water resulting from combustion through bitterly cold exhaust tubes without freezing is somewhat doubtful. The answer to this may be found in radically different explosive actions, unlike anything that we know today, which is not only not impossible but indeed quite probable. Another danger of interplanetary communication is the numerous meteors that travel through space at high speeds.

Notwithstanding these and other difficulties, interplanetary transportation may eventually become a factor in commerce, if, for example, the moon should prove to be a source of rare minerals. Recent astronomical observations would lead to the belief that the moon is expanding rather than shrinking, and this would indicate that it is not the dead, cold body it has always been supposed to be. A probable explanation of the moon's thermal activity lies in the presence of radioactive materials. With radium at the present prices and the possibility of radium mines on the moon, it is not improbable that the future may produce some hardy adventurers who will be willing to take a chance on flying through uncharted lanes of meteorites, for the sake of obtaining this precious element. To the engineer the impossible of today may become practicable tomorrow.

What Next?

ELSEWHERE in this issue will be found a statement by the A.S.M.E. Committee on the Economic Status of the Engineer entitled, "Now We Know Earnings—What Next?"

Readers of MECHANICAL ENGINEERING will recall the report of the committee—"1930 Earnings of Mechanical Engineers"—which appeared in the September, 1931, issue, and the subsequent charts which developed some of the basic data revealed by the answers to questionnaires in greater detail. With the formal submission of the report to the A.S.M.E. at its Annual Meeting in December, 1931, the initial phase of a significant project was completed. The question now is, "What next?"

Engineers who look beyond the statistical information on earnings tabulated in the report, recognize in the investigation which brought out these data the stirrings of a professional consciousness in members of the engineering profession that transcends any interest in their earning characteristics. As important, and definite, and practical as this study was, it is but a starting point for a program of professional development that is in harmony with the purpose and editorial policy of MECHANICAL ENGINEERING. When the committee states that "the greatest significance of the study is the indication it gives that, regardless of his specialty, the mechanical engineer can rarely rise to his full stature in his profession unless he is a 'man of full habit,' " it expresses a conviction about men and the profession that we have always held. To help engineers to develop themselves as "men of full habit" should be the objective of all engineering and professional societies. That the committee has already recommended to the A.S.M.E. Council a definite program of joint action for the development of the individual engineer and the profession he represents—an action in which, we understand, other engineering societies and groups will participate—brings the work of the committee to its second phase and portends significant benefits for engineering.

A hint of what the committee has in mind to accomplish is contained in the statement we have referred to. It is an inspiring program. The spirit of the times is one of reconstruction. Let every engineer exert the pressure of his influence on forwarding the accomplishment of what this program aims to do.

Registration of Engineers

A NOTABLE decision to align itself with certain other engineering societies who have taken an official interest in licensing and registration was recently made by the Council of the A.S.M.E.

The time has passed when it is possible for engineers to hold aloof from this great public question. It is beside the point to argue that engineers should not be subject to licensing and registration by the states in which they practice. The facts of the situation are that in most states such laws are either in effect or are being proposed, and that in many cases the engineer has had or is having little to say about a form of legislation that affects him vitally. Like it or not, we shall have more such laws rather than fewer, and the enforcement of these laws will prove to be more and more burdensome unless properly qualified bodies, such as the A.S.M.E., take a hand and insist that legislation is intelligently and justly enacted. In too many cases have unqualified minorities, through active propaganda and skilful lobbying, been able to write into state laws clauses that are beneficial to their selfish interests, that restrict or prevent the practice of technically qualified engineers, and that are contrary to the best interests not only of the engineering profession but of the public as well. If for no other reason than to counteract the influences of these special interests, professional engineers should take a firm and united stand and work together for wiser and less burdensome legislation. Otherwise they will have largely themselves to blame if through indifference they find themselves legislated out of their profession.

In the resolution presented to the A.S.M.E. Council and passed by it after it had been approved at the Conference of Local Sections Delegates, it was made clear that mechanical engineers are in favor of a uniform licensing and registration bill that will effectively protect the public and that will not divide the engineering profession into categories of practitioners permitted to engage in none but limited lines of work. Engineers should not find it necessary to meet widely different requirements in different states, nor to secure from one to five licenses (as is the case in some states) to practice their profession.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

ENGINEERING MATERIALS

Nickel and Nickel Alloys in Marine Engineering

HEAVY nickel deposits may be produced in such a manner that they show remarkable adhesion to the underlying metals. Tests carried out at the National Physical Laboratory have shown that the resistance to shear of a thick ring of nickel deposited on steel is practically that of the metal itself. In nickel so deposited it is possible to obtain hardnesses of 320 to 350 Brinell.

The paper mentions a case where shafts 10 ft 9 in. long and from 2 ft 8 in. to 1 ft 3 in. in diameter (tapered) were built up $^{7}/_{16}$ in. on the diameter by nickel deposit. The time occupied in forming the deposit was three weeks, after which the shafts were turned to size and the wheels driven on.

Nickel deposits may be applied also for initial production purposes. For example, in expansion sleeves where the deposit enables them to withstand the action of the superheated steam. External surfaces of Diesel-engine liners are also sometimes protected from corrosion by the cooling water by means of a nickel deposit. Two other instances of use of nickel deposits are mentioned: namely, for protection of cast-iron propellers on trawlers, and in alkaline storage batteries.

Nickel non-ferrous alloys are widely used in marine engineering, and the original paper gives data as to their strength at high temperatures. One of the most important applications of the lower-nickel-content alloys is for condenser tubes, and 70–30 cupro-nickel tubes have become standard for installations where water-tube boilers are employed. The finish of these tubes is now in every way equivalent to the best finish obtainable in brass condenser tubes. The original paper contains data on service of brass and cupro-nickel tubes, showing the superiority of the latter.

The paper tells next of monel metal and mentions a test carried out by Monel-Weir, Ltd., in order to demonstrate the absolute freedom of monel metal from anything in the nature of embrittlement after long periods of exposure to superheated steam. A throttle governor valve was taken from a Weir feed pump after 45,000 hr service at 750 F at the Dalmarnock Power Station, Glasgow. This valve showed no trace of cutting action and was in no way embrittled by the above service. An illustration in the original article shows the valve and spindle as withdrawn, the valve after removal and after trepanning a ring of $^{1}/_{4}$-in.-square section from one flange, also the ring flattened by hammering. This flattening gave rise to no sign of surface cracking, even at the sharp edges. The spindle shown was originally made from cold-drawn rod, and on testing after removal was found to have a maximum stress of 43.9 tons per sq in., yield point of 22.5 tons per sq in., and elongation of 42 per cent. This indicates no deterioration in properties.

Brief references are made to nickel-bronze, nickel-silver and light alloys, such as the so-called "Y" and a group of "RR," the composition of which is given in the original paper. This part is interesting as comparatively little on the subject has been published in the United States, but cannot be abstracted because of lack of space. In cast iron nickel is said to produce a more uniform and desired structure, and to improve the machinability by eliminating chill and hard spots in thin sections and at corners and edges. (J. McNeil in a paper before the Institute of Marine Engineers, London, December 8, 1931, to form part of vol. 43, no. 12, Session 1931, 16 pp., 24 figs., abstracted from proof copy, *dg*)

Properties of Alloys Under Dynamic Stresses

INVESTIGATIONS during the last ten years have finally confirmed the fact that most materials, e.g., steel alloys, have a "fatigue limit." That is, if subjected to repeated stresses for any length of time, no failure will occur unless the stresses exceed such "fatigue limit." The term "fatigue limit" is inaccurate, as there is no "fatiguing" effect. The "fatigue" failure is due to single cracks that progress rapidly after and they once started. The material surrounding the final failure, however, is perfectly sound.

Dynamic Strength. The fatigue limit in steel alloys can roughly be estimated as 45 per cent of the tensile strength, though values of more than 110,000 lb per sq in. fatigue limit are seldom observed. This illustrates the fact that very hard and strong steels, as judged from the tensile strength, are not as strong as would be expected under repeated stresses.

Non-ferrous alloys have widely varying fatigue ranges, from 20 to 50 per cent of the tensile strength.

This refers to bending fatigue stresses. For torsion, which is practically of great importance, the fatigue limits for all alloys are between 50 to 60 per cent of the bending fatigue limit.

Effect of Notches, Flaws, Corrosion, Etc. The results reported are obtained from specimens with a carefully polished surface. Poorly machined surface reduces the fatigue limit considerably. So do accidental small notches, flaws, inclusions, and other imperfections of finish. The situation is very complex, as the same notch has greatly different effects on different materials. And for the same material, a notch can have quite a different effect from that of a second notch of identical dimensions but produced by another tool. Mathematical analysis of "notch effect" does not help a bit. Only tests can give information about this notch sensitivity or "tenderness." Notches and flaws are bad enough for the endurance life of materials, but corrosion is terrific. It may reduce the fatigue limit to one sixth of its normal value, that is, to about 8 per cent of the tensile strength. Heat treatment does no particular benefit also in this case.

Dynamic Ductility. The notch effect seems to be related to the ductility of the material, but not to the ordinary ductility as measured by impact tests, or the elongation in tensile tests. These tests break the specimen with a single load, and create an entirely different kind of fracture from that obtained in the fatigue test. The "dynamic ductility" is that amount of plastic yield that the material shows within the fatigue limit. Such ductility is quite different from the usual conception of toughness. New tests have been devised to study this effect,

which seems to be a valuable addition to our knowledge of fatigue phenomena. The "dynamic ductility" has also been called "damping capacity" or "crackless plasticity." A machine is available that permits determining this newly detected property.

Means of Improving the Endurance Properties. The fatigue limit of most materials can be raised about 20 per cent by replacing the polishing finish by a novel method of cold rolling, intended to cold-work the surface. This method raises the strength of the outside fibers that receive the maximum stress. It also sets up beneficial internal stresses so as to reduce the maximum tension stress.

The method referred to is of particular profit where notches are unavoidable such as threads. It is possible to increase the fatigue strength of screws subjected to bending, by 20 to 65 per cent, the lower figure applying to soft materials and the higher percentage to high-quality alloy steel. Here we have the extraordinary case that internal stresses can be beneficial if they are produced intentionally and correctly. (G. S. von Heydekampf, in a paper before the *Metals and Alloys Conference* at Case School of Applied Science, Cleveland, Ohio, Nov. 18–20, 1931; abstracted from mimeographed preprint, *g*)

Promal—A New Type of Cast Iron

THIS is a new type of cast iron placed on the market by the Link Belt Company, of Chicago, Ill. The method of its manufacture is described in two U. S. patents, Nos. 1,760,240 and 1,760,241, issued to Carl F. Lauenstein, of Indianapolis, Ind. The metal is described as being a granular ferrous metal including grains of free ferrite, graphitic carbon, and iron carbide, the latter being distributed between the grains of ferrite and about a graphitic carbon. To obtain the best results the metal must be treated in a certain way.

The characteristic feature of this metal, as partly evident from the above, is that there is distributed throughout it along the grain boundaries and about such particles of graphitic carbon as are present, an agent which tends to stiffen the grains and prevent their distortion under stress. This is claimed to strengthen the mass and prevent the separation of the grains. This agent is an iron carbide, normally pearlite or sorbite.

The metal in this case may be formed from such iron as white cast iron. It may have an average chemical composition of 2.30 per cent combined carbon, no graphitic carbon, and, say, 0.90 per cent silicon. The heat treatment includes the following steps: Malleabilized cast iron is heated to a temperature in the neighborhood of 1475 F and is held at this temperature for a time depending on the size of the part treated. The important thing is to bring the material to a temperature above the "critical" or carbon combining one. After the heating has been carried on for a sufficient time the material is cooled in air or quenched in oil, water, or similar media. After the quench it is reheated to a temperature sufficient to break down the martensite or troostite which has been retained after the first heating into pearlite or sorbite. This change takes place in a temperature range of 900 to 1200 F (approximately). After this treatment the material contains 0.40 per cent combined carbon and 1.50 per cent graphitic carbon. It is claimed that as a result of the treatment the material consists of pearlite and graphitic carbon, whereas the original cementite has been changed into ferrite. The pearlite is spread about through the body of the metal and particularly within the grain boundaries, which strengthens the entire body of the metal. It is also claimed that as a result of the treatment there is built up throughout the body of the metal a reversing framework of iron carbide, the cells of which surround the weaker grains of the ferrite. The iron carbide is likened to a honeycomb within the cells of which are found the grains of ferrite. (U. S. Patents, 1,760,240 and 1,760,241 to Carl F. Lauenstein, and 1,760,239 to Carl F. Lauenstein and Neil M. Waterbury, *d*)

FUELS AND FIRING (See also Internal-Combustion Engineering: The Combustion Temperature of Powdered Coal and the Possibility of the Coal-Dust Engine; Internal-Combustion Engineering: The Coal-Dust Engine)

The Mechanism of Combustion of Solid Fuel

IN AN ATTEMPT to arrive at an understanding of the kinetics of the reactions involved in solid-fuel combustion, the authors of the paper under consideration advance a theory, which has to do, however, only with the combustion of the non-volatile portion of solid fuel.

They start with consideration of the following question: Given a sphere of carbon which is suspended in an atmosphere containing a fixed amount of oxygen kept at a constant temperature, what will be the rate of combustion of the sphere? In the past it has been assumed that a hot body immersed in a cooler fluid is surrounded by a relatively stationary or stagnant fluid film, outside of which turbulent motion is maintained by convection currents.

Accordingly, therefore, if a sphere of non-volatile combustible material were immersed in an oxygen-containing atmosphere, and if combustion were proceeding uniformly on the surface of the solid, the formation of a stationary film of the atmosphere around the solid might be expected. If this condition should actually obtain, the combustion of the sphere would then proceed by the diffusion of oxygen through the film to react at the surface of the sphere. If the sphere is composed of carbon, the oxygen might react at its surface to form carbon dioxide, which in turn would diffuse outward through the film to disperse in the turbulent atmosphere at the external boundary of the film. On these assumptions, then, the rate of combustion will be controlled by the rate of diffusion of the oxygen and of the carbon dioxide through the film, provided the rate of chemical reaction is rapid compared with the rate of diffusion. The heat generated at the solid surface is the heat of reaction at the temperature of the surface, and the energy so liberated tends to raise the temperature of the solid and of the film. Heat is lost, however, by conduction through the film of the turbulent fluids, and by direct radiation to the furnace wall. In the final analysis, therefore, the rate of combustion will be controlled by the composition of the atmosphere; the pressure; the temperatures of the sphere, the ambient fluid, and the furnace walls; the size of the sphere; the thickness of the film; and similar factors.

On the basis of the foregoing theory, it was found possible to obtain mathematical expressions relating the rate of combustion of fuel particles with the ambient temperature of the furnace, the composition of the atmosphere in which combustion occurs, and the size and density of the carbon particle. Taken as a whole, the deductions based upon the theory were in striking accord with the experimental results of Griffin, Adams, and Smith. The significant points of agreement may be summarized as follows:

1 The times of combustion calculated from theory, when compared with experimental measurements on a wide variety

of fuel particles, not only indicate the correct relative order of rapidity of combustion, and predict the proper magnitude thereof, but actually agree with the measured values well within the unavoidable errors of calculation and experiment.

2 The effects of all the variables studied experimentally are strictly in accord with the predictions of the theory.

3 The peculiar motion of the particles predicted by theory is fully confirmed by the photographic records of the experiments.

In the course of the work it was felt desirable to consider the effect on the mechanism of combustion of the formation of carbon monoxide at the surface of the burning particle. Both experimental evidence and thermodynamic considerations indicate the presence of both carbon monoxide and carbon dioxide at the surface of the burning sphere. From this a picture of the mechanism of combustion is built up, in accordance with which oxygen does not reach the surface of the carbon, but instead the carbon is consumed by the reduction of CO_2 to form CO. It is expected that the relative amounts of CO and CO_2 formed at the carbon surface will probably be functions of the temperature of the surface as well as functions of other variables, such as the presence of catalysts, either in the carbon itself or in the atmosphere in which combustion occurs.

The mathematical treatment gives three equations from which to determine the reaction velocity, the temperature at the surface of combustion, and the film thickness, the values of the constants involved in these equations being given in the original article. The equations which can be directly used for calculation are those numbered in the original article as 26, 27, and 28, and the method of calculation is illustrated by an example. The authors state that if their theory is correct, then it seems probable from results obtained that there is a definite ratio between the CO and CO_2 at the carbon surface. Neither the experimental results nor the theoretical analysis are accurate enough, however, to determine whether this ratio changes with change of surface temperature, as might readily be expected. The presence or absence of water vapor in the air seems to bring about a change in this ratio, in that the addition of water vapor to dry air apparently causes the CO_2 concentration at the carbon surface to increase.

The methods of applying the same process to the calculation of combustion of pulverized fuel are given in the original article. From these it appears that in all cases the time of combustion is practically directly proportional to the square of the radius of the particle.

Attention is called to the fact that whereas the original theory gives a negative temperature coefficient in accordance with the experimental facts, the present theory indicates a slight positive temperature coefficient.

The discrepancy between the theory and experiment in this case must be sought in the approximate character of the calculations. (B. P. Burke, Director of Industrial Science Division, West Virginia University, Morgantown, W. Va., and T. E. W. Schumann, Director of Fuel Research Institute of South Africa, Pretoria, S. A., in a paper before the Third International Conference on Bituminous Coal, Pittsburgh, Pa., Nov. 16 to 21, 1931; abstracted from printer's proofs; *tm*)

INTERNAL-COMBUSTION ENGINEERING

The Combustion Temperature of Powdered Coal and the Possibility of the Coal-Dust Engine

IN USING special apparatus for determining the self-ignition temperature of various fuels, it was found that there is a marked difference in the self-ignition temperatures, depending on the type of fuel, and it would appear that the ignitibility is closely related to the percentage of volatile matter in coal and lignite. The combustion time is reduced with the increase of temperature, and the character of the reduction varies with the type of fuel. Fuels of low self-ignition temperature are likely to have a greater rate of reduction, while the combustion time of Diesel oil remains almost constant.

All the experiments described above were carried out under a pressure of 10 atm, but as the combustion properties change with pressure, additional experiments were made under various pressures, namely 5, 10, 15, 20, 25, 30, and 35 atm (gage pressure), respectively. These tests afford evidence that the auto-ignition temperature decreases rapidly with an increase of pressure, especially within the range lower than 10 atm.

The highest pressure rise was given at a pressure of 10 or 15 atm with coal, and at 25 or 30 atm with charcoal. At the stated pressures, the analyses of combustion gases nearly coincided with the percentage of carbon dioxide and oxygen calculated from the compositions of the fuels.

The depression of the auto-ignition temperature is very remarkable with coal or charcoal, and coal No. 28 ignites at a temperature lower than that of low-temperature tar distillate under pressures higher than 20 atm. It was found, in a previous investigation at the author's laboratory, that this coal could be used in a Diesel engine without any difficulty, even under heavy load.

The fact that the auto-ignition temperature of pulverized fuel is remarkably depressed under high pressures suggests that the coal-dust engine should have a compression ratio higher than that of ordinary Diesel engines in order to secure the easy and complete combustion of fuel. In this connection, a system having a combustion chamber is desirable in the design of the coal-dust engine. A high compression ratio and a precombustion chamber may increase the cost of construction, but it will be quite a small factor compared with the total cost.

Finally, the combustibility of pulverized fuel is naturally influenced by the degree of fineness or the size of the particles, as shown in the following table:

Fineness	5 atm	10 atm	20 atm	30 atm
	—Degrees centigrade—			
100- to 200-mesh	544	510	488	439
200- to 250-mesh	510	465	438	420
250-mesh and over	493	438	404	394

So far as the combustibility is concerned, it is desirable to pulverize coal as fine as possible. But it must be borne in mind that such a fine powder as will pass through a 250-mesh sieve cannot be stored for a long time, because it tends to absorb much moisture during prolonged storage and must be dried before use, which is accompanied by a considerable elevation of the auto-ignition temperature. The temperature of drying also influences the rise of the auto-ignition temperature. The auto-ignition temperature of coal No. 1, for instance, was elevated from 458 C to 484 C by heating at 200 C for half an hour. (Tetsuro Suwa, Research Engr. of the Imperial Fuel Research Institute, Saitama-Kawaguchi, Japan, in a paper before the Third International Conference on Bituminous Coal, Pittsburgh, Pa., Nov. 16–21, 1931, 9 pp., 6 figs., abstracted from preprint, *e*)

The Coal-Dust Engine

TWO papers on this subject were presented at the Third International Conference on Bituminous Coal, Pittsburgh, Nov. 16–21, 1931. The first by Rudolph Pawlikowski, presi-

dent of the Kosmos Engine Works, Görlitz, Germany, dealt with the Rupa engine and described the work done since 1916. The most recent improvement has been the provision of an auxiliary chamber, the purpose of which is to provide sufficient suction to handle the coal dust. It is claimed that with this auxiliary chamber the engine ignited widely different fuels, such as brown coal and bituminous coal, without any special additions, and that no compressed air for injection of fuel was used.

The Kosmos Company has been able to operate its first 80-hp Rupa engine with vegetable powders, such as meal made of Italian *sanzza* (extraction residue and ground kernels from the manufacture of olive oil). As regards the auxiliary chamber referred to above, the following may be of interest:

The fuel is introduced into the auxiliary chamber before compression is started: in the four-stroke cycle during the suction period, and in the two-stroke cycle at the time when the working cylinder is being charged with fresh air. The auxiliary chamber, therefore, is an addition to the engine cylinder or a waiting room for the fuel, which is prepared for ignition there by the air in the engine cylinder, which during compression penetrates the auxiliary chamber with increasing temperature.

The new term "auxiliary chamber" is used to distinguish the space in question from the well-known ante-room in which the fuel oil in Diesel engines is compressed only at the end of the compression period, but which does not constitute a waiting room giving an opportunity to lag. No greater quantity of fuel, whether it be powdered coal or gas oil, can be ignited in the auxiliary chamber than corresponds to the quantity of oxygen in that chamber. Its quantity depends on the volume of the chamber and the final compression pressure in the engine cylinder, and also on the additional quantity of oxygen that has been introduced into the auxiliary chamber from the outside, either as injected compressed air or as intermediary air admitted during the period the chamber is charged with fuel.

This volume of oxygen in the auxiliary chamber therefore determines the small partial fraction of the total fuel charge introduced into the auxiliary chamber, which fraction raises the pressure within the auxiliary chamber beyond the final compression pressure in the engine cylinder, and injects the charge into the latter.

As most of the oxygen from the engine cylinder is determined by the degree of compression, and as this amount remains almost constant for all engine loads, practically the same injection pressure occurs in all cases, and consequently also the same effectiveness of injection, for idling as well as for full load.

The beginning of ignition in the auxiliary chamber and the injection therefrom depend mainly on the size of the auxiliary chamber. Comprehensive investigations showed that the following approximation was applicable to the most favorable size of the auxiliary chamber for different final compression pressures: namely, that the ratio of the volume of the auxiliary chamber to the compression space at the end of compression should be about the same as the ratio of the compression space to the total volume of the engine cylinder at the beginning of compression.

In each case the volume of the auxiliary chamber, calculated on the basis of this formula, must be adapted to still other factors, such as the ignition temperature of the fuel, the fineness of the fuel powder, the shape and method of cooling the walls of the auxiliary chamber, the resistance of the injection nozzle, etc.

In fact, the larger the size of the powder grains, and the narrower the adjustment of the nozzle, the larger must be the increase in the volume of the auxiliary chamber over the figure found by applying the above formula, in order to make ignition occur at the correct moment. Also, the auxiliary chamber must be given a different volume if the fresh air has a pressure above that of the atmosphere when it enters the engine cylinder.

With normal final compression pressures of 22 to 36 atm, the volume of the auxiliary chamber is about 1.5 to 0.4 per cent of the fresh-air volume of the engine cylinder.

Indicator diagrams of the auxiliary chambers were often taken by the Kosmos Company at the same time as those of the engine cylinder, using a special type of indicator. Some of these diagrams are reproduced in the original paper, but are not available for inclusion in the present abstract.

The seventh Rupa engine has now run nearly 1000 hr on the hydraulic brake with an average load of about 130 hp in daily and continuous operation. For months it was running 10 to 14 hr daily and was frequently tested in non-stop runs of 80 to 90 hr. The following results are of practical interest:

The coal consumption per brake horsepower-hour does not have a minimum at the so-called normal load of 133 bhp, but continues to drop somewhat further from this point toward the maximum load, which is assumed to be about 170 hp, due solely to the heating of the transmission mechanism, and corresponds to an average indicated pressure of about 8 atm.

The lubricating-oil consumption was found to be about 4 g of fresh lubricating oil per brake horsepower-hour for run-in piston rings, if the waste oil of the piston is not used again. Most of the waste oil may be purified by settling, heating, filtering, and centrifuging until it has almost the original lubricating power. It may thus be used again, and the consumption of fresh lubricating oil may be reduced in this manner to 1.0 to 1.5 g per bhp-hr.

The gases leaking from the cylinders of Diesel engines and gasoline engines blow more particles of liquid-fuel vapor between the piston rings as the latter begin to break. These small drops become attached to the metal surfaces between the piston-ring grooves and piston rings, and by their viscosity increase the resistance to leakage of the cylinder gases. These engines therefore have an automatic remedy for leaking pistons.

On the other hand, the leakage gases in the Rupa engine do not carry oil drops into the spaces between the piston-ring grooves and the piston rings but glowing grains of coal and ash. Because of the centrifugal action to which these grains are subjected in being deflected by the numerous edges of the grooves and rings, they are sifted from the gas flow in accordance with their size, and by their glowing heat they cause local evaporation of the lubricating oil. Consequently the resistance of the lubricating oil to leakage of gases is reduced with increasing leakage of the piston rings. The automatic remedy inherent in the oil engine is therefore totally absent. The more the piston rings leak, the more ash grains are blown between the rings, causing the latter to wear.

The Rupa engine requires considerable further development in the present type of snap rings and better forced introduction of the lubricating oil between the piston rings. These designs are said to have been worked out and are now being tested in continuous operation. The Kosmos Company has also under test a new design for the cylinder lining made of hardened steel. The manufacturing cost of a Rupa engine is somewhat higher than that of a Diesel engine, because of the coal-dust adapter. The weight is about the same, as are also the floor

space required and the capacity per cubic unit of displaced volume per second.

A comparison of cost of installation and fuel between steam, Diesel, and Rupa engines is given in some detail in the original paper. It is claimed that the Rupa engine produces a kilowatt-hour at a cost about 26 per cent less than the steam turbine. The delay in the introduction of the Rupa engine is ascribed by the author to the opposition exerted by the large oil companies and coal-mining companies, and hesitation on the part of engine users to accept a new type of motor without special guarantees. (Paper before the Third International Conference on Bituminous Coal, Pittsburgh, Pa., Nov. 16–21, 1931, abstracted from galley proofs, with illustrations, *d*)

Marine Oil Engine Trials Committee—Sixth Report

THIS report was presented in November, 1931, at a meeting of the Institution of Mechanical Engineers in London, and covers the tests made on the twin-screw motor vessel *Polyphemus*. The previous report on the motorship *Dolius* was abstracted in MECHANICAL ENGINEERING, vol. 47, no. 6, June, 1925, p. 504. The *Polyphemus* is a combined cargo and passenger ship with a fully loaded displacement of 12,804 tons. Its propelling machinery develops 5500 shp at 138 rpm, giving an estimated surface speed in the fully loaded condition of 14.75 knots. The engines are of the four-stroke-cycle single-acting type, and each has six cylinders supercharged on the Büchi system by means of centrifugal blowers driven directly by exhaust-gas turbines at the end of the exhaust manifolds.

The Committee carried out its tests in two sections—tests ashore and tests at sea. On shore the port engine was put through an extensive series of calibration tests, and from the data so obtained the behavior of the engines when running in the ship at sea was inferred where it could not be directly measured. These tests were carried out at various loads and speeds which were arrived at on the assumption that the torque of an engine is proportional to the square of the speed.

One of the tests at sea dealt with fuel-consumption runs at surface speed and at full speed. The data of the tests are presented in the form of tables. An interesting feature of the tests ashore and at sea is presented by the records of the torsional oscillations of the crankshaft obtained by means of a Geiger torsiograph. An analysis of these records is presented in an appendix, from which it appears that the error between the observed and calculated frequencies was of the order of 2 per cent. In the discussion which followed, S. B. Freeman remarked that if the engines of the *Polyphemus* were to be redesigned they would probably be modified in the direction of fitting them for airless injection. A chain drive would perhaps be used to operate the camshaft in place of the coupling-rod system that had been adopted.

James Brown stated in reference to the supercharging equipment that the nearer the blower was placed to the engine, the better would be its performance. It had been found that the port blower always ran faster than the starboard blower. The cause had been traced to a difference in the length of the exhaust pipes on the two engines.

Prof. A. L. Mellanby dealt with the torsional-oscillation investigation presented in the appendix. The old-time marine engineer accustomed to slow triple-expansion steam engines never dreamed, he said, of torsional oscillation, although it was just possible that some of the mysterious crankshaft failures which occasionally perplexed him were caused by it. In internal-combustion engines, however, the conditions were greatly different. Rupture was practically certain if the running speed happened to be in consonance with one or other of the critical speeds. Carter's formula for determining the uniform shaft equivalent to a crankshaft, in the light of the results detailed in the appendix, appeared to give a close approximation to the truth. He urged the necessity for investigating all critical speeds, whether of minor or major order. The minor orders, he contended, could not be neglected with safety.

W. A. Tookey expressed his faith in the ability of the figures given in the report to stand analysis. In the case of the fifth report, the indicator diagrams had been severely criticized, but in the *Polyphemus* trials, both ashore and at sea, all precautions had been taken to secure accurate results. In addition, the shore-trial results had been compared with the results of tests made by Prof. C. J. Hawkes, and agreement had been found at every point. He (Tookey) had recently tested a similar design of engine of the airless-injection type, and when he compared the Committee's results with his own on a mixture-strength basis, he found equally good agreement. The fact might perhaps be encouraging to Mr. Freeman if he wished to adopt airless injection. Regarding torsional oscillation, he recalled an instance in which a flywheel of reduced weight had been fitted to an engine because of synchronism between its running speed and the critical speed of its crankshaft. Had it only been known, an alteration in the firing order of the cylinders would have secured the same result.

Attention to the importance of fuel and lubricating-oil separators was called by Engr. Lt-Com. H. S. Humphreys, who also stated that the calorific values of the fuel given in the report were the gross values.

Wing Commander Cave-Brown Cave told the meeting that Carter's formula had been deduced to predict the torsional period of aircraft-engine crankshafts. He suggested that it would prove equally useful to marine engineers if they used the Farnborough indicator on their engines. In aircraft engines the solution to the problem of securing efficiency had proved to be the use of gearing between the engine and the propeller. A similar solution might be applicable in the case of marine oil engines. The use of gearing with such engines would, he predicted, be found to produce a remarkable saving in space and weight.

A. E. L. Chorlton said that the German battleship *Deutschland* had geared internal-combustion engines. These engines ran at 450 rpm and the reduction ratio of the gearing was four to one. The weight of the machinery was about 20 lb per shp. From other information it appears that the engines of the *Polyphemus* showed a fuel consumption of 0.397 lb per bhp-hr as compared with 0.353 lb in the case of the *Dolius*. These figures seemed to raise the question whether there was any advantage in using a supercharger in place of recovering waste heat by the generation of steam as in the Scott-Still engines. Replying to this remark, Sterry B. Freeman said that the engines of the *Dolius* were still doing good work and showing a fuel consumption of from 0.36 to 0.37 lb per bhp-hr, but they cost more to build and repair than ordinary engines. A 20 per cent saving in her fuel bill would represent £1000 a year. When that saving was capitalized it was not sufficient to meet the extra cost of the engine.

In reply to a previous discussion dealing with the oil coefficient used in estimating the efficiency of propulsion, Mr. Freeman said that the figure of 64,000 has been arrived at by using the formula: displacement^2 × speed^3 × fuel per day. The figure was an empirical one, but the numbers could be obtained accurately, whereas it was not possible to get the horsepower accurately all the time. In this case the designed speed, designed draft, and designed fuel consumption of 0.397

lb was taken. (Report to the Institution of Mechanical Engineers, presented Nov. 20, 1931, in London; abstracted through *The Engineer*, vol. 152, no. 3959, Nov. 27, 1931, pp. 566–569, and *Engineering*, original report, first part, vol. 132, no. 3437, Nov. 27, 1931, pp. 680–682, and discussion complete, pp. 676–678, *d*. The account in *Engineering* is the more complete.)

MACHINE-SHOP PRACTICE

Experiments on the Cutting of Metals

THE present writer has devised a new method for measuring exactly both the vibration of the tool and the cutting force. With his device he measures the deflection produced when the cutting force acts on a lathe tool. There is a certain relation between the load and the deflection of a rod built rigidly into the tool holder. To measure the deflection a special tool holder and a rectangular rod were used. A piece of mild steel was soldered to the end of the rod and a small mirror was placed between this piece and a support fastened to the tool holder. The deflection of the rod was measured in this way. It was found that there is a linear relation between the load and the total deflection of the rod. If the rod is built rigidly into the tool holder the deflection angle of the rod is $\theta = Pl^2/2EI$, where P is the load, l the length of the rod, E the modulus of elasticity, and I the moment of inertia.

The cutting force of the tool can be calculated by the measurement of its deflection or its deflection angle, a photographic process being employed.

Besides the vertical cutting force, there are generally two other components, a traversing and a surfacing one. The traversing component is proportional to the deflection angle of the edge in the traversing direction, and can be ascertained by measuring the deflection angle in that direction. The surfacing component can be measured also by using the same tool and tool holder that were employed in the previous experiment.

This new measuring method seems to be better than the ordinary methods employed by several experimenters; it does not give rise to any error due to the inertia of the moving parts of the measuring apparatus such as occur in the case of the brake method, the balance method, and the diaphragm method. Moreover there is no trouble about leakage as in the piezoelectric method. Further, there exists a linear relation between the cutting force and the deflection angle of the tool, whereas in the capacity-change method there is no such relation between the cutting force and the reduced electricity, making it difficult to know accurately the change of the cutting force.

Among the results obtained the following may be mentioned. As to effects of cutting speed and depth of cut on the cutting force and the vibration of tool, the former are shown in the original article in a series of graphs. At slower cutting speeds the tool does not vibrate, but when the cutting speed increases the tool vibrates very regularly in a small period and the amplitude of the vibration increases gradually. Due to this vibration of the tool an irregularity is produced on the cutting surface. The change of the cutting force synchronizes with the natural frequency of the tool.

It is not demonstrable whether the metal is cut intermittently at the lower or higher position of the cutting edge, or whether continuously by the cutting speed which is accelerated or retarded according to the vibration of the cutting edge. Thus from the figures obtained it is difficult to calculate exactly the mean cutting force. For convenience it is assumed that the mean cutting force acts in a way proportional to the mean displacement of the tool. Therefore there is a suggestion of a decrease of the cutting force where synchronization occurs.

The natural oscillation of the saddle due to its sliding surface synchronizes with the fluctuation of the cutting force according to the cutting conditions, and the metal is cut intermittently, producing an irregularity on the cutting surface.

The natural frequency of the lateral vibration of the work synchronizes with the fluctuation of the cutting force, according to the size of the work and the cutting conditions. In this case the tool vibrates regularly in a large amplitude, producing an irregularity on the cutting surface. In the extreme cases when this vibration occurs seriously, cutting is not possible.

When mild steel is used as the work material there are two distinct types of chip, namely, the flow type and the shear type. In the formation of the flow type of chip a deformed zone appears on the cutting edge and the metal is cut smoothly. In this case the vibration of the tool and the cutting force are at a minimum, so that this is the most favorable cutting condition. In the case of the shear type the cutting force fluctuates on account of the shear of the chip, and the tool vibrates irregularly in a large amplitude.

The magnitude of the cutting force is affected greatly by the change of the cutting action, and in the range of the same cutting action the cutting force is nearly independent of the cutting speed. (Shizuo Doi in *Memoirs of the Ryojun College of Engineering*, vol. 4, no. 4A, 1931, pp. 243–255 text, 12 figs. and 7 plates of illustrations, *e*)

Tungsten Carbide Tools

IN CONNECTION with the design of new tools intended to be used with tungsten carbide cutters, certain trials have been carried out at the works of Alfred Herbert, Ltd., Coventry, England.

The tools themselves are built up with the Widia tip fixed in a recess cut in a mild-steel shank. The shank is coated in the recess with a powdered flux and is placed in a preheating furnace at a temperature of 900 C. The shank is then removed and the recess cleaned with a wire brush. Brazing compound is placed in the recess and the shank is put into a second furnace at a temperature of 1050 C until the brazing compound is melted. The shank is then withdrawn, the Widia tip placed in position with a little brazing compound on the top, and the tool is returned to the furnace until the fresh compound is melted. It is then withdrawn and the tip pressed firmly into its seat by means of a notched bar. When the tipped tool has cooled, it is taken to a grinding machine where the cutting edge is roughly ground. At present the final operation is performed on a specially fine grinder which gives a clear polished surface and sharp cutting edge, but experiments are being conducted to investigate the advisability of lapping. The firm considers that the finer the finish on the tool, the better the results to be obtained on the machine. A table in the original article gives some figures taken from the results of tests carried out with Widia tools on a 33-in.-swing combination turret lathe. One of the illustrations in the article shows this machine operating with four tools, two on the turret slide, each taking a $\frac{1}{2}$-in. cut in the bore; and two in the tool post, each taking a $\frac{1}{2}$-in. cut on the outside. As the thickness of the cylindrical iron casting being machined was originally 4 in., about one-half the total metal is removed in one operation. The figures in the table are very interesting. Speeds up to 200 ft per min were generally used, although the

tools are capable of standing up to considerably higher speeds. With four tools in operation material was removed at the rate of 274.9 cu in. per min with a gross input of power of 71 bhp. An inserted-tooth milling cutter with Widia tips is illustrated in the original article, and data of tests are given showing surface speeds as high as 264 ft per min with depth of cut from $^1/_8$ to $^3/_{16}$ in. and travel per minute of $26^3/_4$ in. for the former and $15^1/_2$ in. for the latter.

The firm is continuing the tests on the tools and has already come to some interesting conclusions. Widia tools will stand up to any amount of compression, but any rubbing or tension very soon destroys the cutting edge. For this reason, if such tools are used on a machine of which the bearings show signs of wear, or if any undue vibration occurs, results will be unsatisfactory, and possibly less impressive than those obtained from high-speed steel. In addition, the opinion was heard expressed that Widia tools can be run at too slow a speed, when the wear will be unduly rapid and the results unsatisfactory. (*The Engineer*, vol. 152, no. 3960, Dec. 4, 1931, pp. 603–604, 4 figs., *de*)

MARINE ENGINEERING (See also Engineering Materials: Nickel and Nickel Alloys in Marine Engineering; Internal-Combustion Engineering: Marine Oil Engine Trials Committee—Sixth Report)

The Benson Marine Boiler

A CRITICAL-PRESSURE boiler of the Benson type has been installed on the Hamburg-American liner *Uckermark*. This is a 9000-ton steamer, and the boiler has displaced one of the old boilers and has sufficient capacity to generate all the steam required to operate the vessel. A high-pressure turbine was added, coupled ahead of the existing 220-lb turbine.

The boiler tubes exposed to radiant heat from the surface are of molybdenum steel and are welded to 32 forged open-hearth-steel headers which divide the boiler into 16 sections, each consisting of an upper and lower header joined by 11 vertical tubes. The superheater and economizer sections of the boiler are built with seamless open-hearth-steel tubes. The vertical tubes exposed to the furnace heat are protected by special alloy ("nichrotherm") plates. The entire Benson boiler weighs only 110 tons, while the total water and stream within the boiler weigh about 1.1 tons. In contrast thereto the original boiler displaced by the Benson unit weighed 171 tons and had only one-third the steaming capacity of the latter. The feed input of the boiler is governed by the steam output, and an automatic reducing valve is provided to maintain a constant boiler pressure of 3250 lb per sq in. (*Zeitschrift des Vereines deutscher Ingenieure*, vol. 75, no. 47, Nov. 21, 1931, p. 1433. Compare *Power*, vol. 74, no. 24, Dec. 15, 1931, pp. 870–872, *dA*)

MECHANICS

Analytical Study of Crank Effort in Reciprocating Engines

THIS is a mathematical paper that does not lend itself easily to abstracting because of its demands on space. The crank effort of a reciprocating engine is usually found by graphical methods which are suitable only in the case of a constant engine speed and essentially neglect fluctuation of speed during the cycle itself. The analytical procedure adopted in this paper gives directly the expressions for the unbalanced forces and the crank effort without neglecting the speed fluctuation within the cycle. The inertia and gravitational effects of the connecting rod and reciprocating parts are also considered here. For this purpose the moment of inertia of the connecting rod must be determined, and the author gives a method therefor. He starts with a consideration of the motion of the piston and derives expressions for the piston velocity and acceleration. These equations involve the use of certain constants for which values are given in tables in the original article. By way of example the method is applied to the calculation of a four-stroke-cycle single-acting Richardsons-Beardmore-Tosi engine and the two-stroke-cycle double-acting Scott-Still engine.

The motion of the connecting rod is considered next, and expressions are obtained for its angular acceleration. Here again the values of the constants are given.

The author proceeds next to find expressions for the working-fluid pressures in terms of crank angles as trigonometric functions. This permits calculating from an indicator diagram the ratio of piston displacement to stroke for every sixteenth of a revolution, and from this are derived the values of the effective fluid pressure and of the numerical coefficients.

Incidentally, it is shown that the turning moment due to the fluid pressure on the piston is the product of piston pressure × piston velocity, the latter taking a negative sign during the compression and exhaust strokes with the result that the turning moment itself becomes negative.

When the angular motion is not constant the inertia effect of the moving masses comes into play. The angular velocity of the connecting rod is always changing whether the engine speed is constant or not. In such cases the polar moment of inertia of the connecting rod must be found, and the author proceeds to do this analytically, pointing out, however, that it can be also determined experimentally by making use of the principle of the pendulum. He obtains an equation of the angular displacement of a pendulum oscillating against two damping effects, of which one is constant and the other is proportional to the angular velocity of oscillation, and from this derives an expression for the period of oscillation, as well as a complete expression for the polar moment of inertia.

The inertia effect of the connecting rod is considered next, and a formula for the "correction couple" is found. Expressions are also found for the gravitational effect of the connecting rod on the crank effort in single-cylinder and multi-cylinder engines. Examples of numerical calculation are given throughout. The inertia effect of the reciprocating mass of the connecting rod and piston is considered in connection with what the author terms an "equivalent polar moment of inertia," which is the polar moment of inertia of all the moving parts in the running engine reduced to the main crankshaft. He uses this conception for the calculation of the speed fluctuation of the engine shaft.

The next subject to be considered is the crank effort due to pressure of the working fluid, and when this has been obtained an expression is given for the resultant torque due to inertia and gravitational effect of moving parts, together with that due to fluid pressure of the piston. Here the expression is given for the ratio of the maximum fluctuation of energy to the mean torque. In all of the above calculations it is assumed that the engine runs at constant speed, but the formulas are also applied to the case when the engine is allowed to run freely as it goes. This results in a table and a series of graphs (Fig. 13 of the original article) showing the resultant crank effort and energy fluctuation.

An interesting part of the paper is that devoted to a discussion of the frictional resistance affecting the torque of the main crankshaft and occurring at the piston crosshead, gudgeon

pin, crankpin, and main bearings. The figures thus obtained are checked against figures already available. (Akira Kobayashi in *Memoirs of the Ryojun College of Engineering*, vol. 4, no. 3, 1931, pp. 129–183, 24 figs., and 18 tables and plates, *tmA*)

MOTOR-CAR ENGINEERING

The Ransome-Garrett Transmission for Commercial Vehicles

PARTICULAR interest attaches to this transmission, which is by means of Ransome-Garrett patented tubular propeller shafts and universal joints, with splined couplings at the axle end. The drawing reproduced in Fig. 1 shows a section

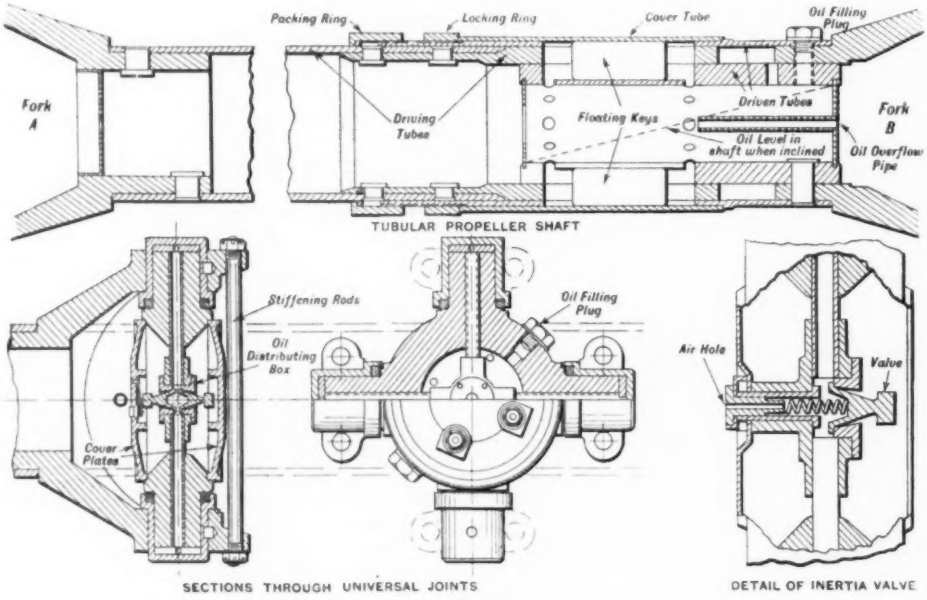

FIG. 1 PROPELLER SHAFT AND UNIVERSAL JOINT IN THE RANSOME-GARRETT TRANSMISSION

through the shaft and the universal joint, with an enlarged detail of the inertia or oil-dosing valve. The new drive has been designed to work over long periods at angles from 10 deg to 12 deg under high loading conditions, and shafts of this pattern have now, we learn, been in operation over two years with entirely satisfactory results. The shaft has a high factor of stiffness, and the weight is not excessive. The mean diameter of the tubes, which transmit the drive, is 4 in., which gives a torque-transmitting surface of, roughly, twice the radius of the usual splined shaft, with bearing pressures about half the usual figures. The drive is transmitted from the fork *A*, through the driving tubes, which are riveted together, through floating keys to the driven tubes, which are secured to the fork *B*. The tubes are enclosed by a cover, which acts as an oil retainer, and is kept in position against a shoulder by the locking ring shown.

The method of producing this portion of the shaft is, briefly, as follows: The tubes are ground internally and externally so as to telescope freely but without side play. They are then assembled and holes at the ends of each key slot are drilled and reamed so as to give a dead-smooth finish. This is done to avoid any notch effect, which might give rise to fatigue fractures when the shaft is in service. The tube assembly is then placed in a special machine, and the slots are end-milled through the three thicknesses at one setting. Accurate indexing, and the fact that the slots are cut with the three tubes in their proper relative positions, insures that in the finished shaft each key transmits its proper share of the load. The keys are slightly shorter than the slots in which they slide. With the shaft inclined in the working position so that the fork *B* is lower than the fork *A*, the central chamber forms an oil bath, the maximum level being determined by the oil overflow pipe. A filling plug is also provided. The oil is prevented from creeping along the shaft by a disk at the end of the oil chamber, and from being thrown out externally by the packing washer and ring shown. A feature of the design is that the telescopic portion of the shaft cannot pull apart, although it can be conveniently inspected. The hardened and ground keys can be easily renewed, while, if necessary, the slots and keys can be made oversize in order to prolong the life of the shaft, should wear take place.

The universal joints also embody new features as regards their construction and lubrication. As Fig. 1 shows, the universal joint comprises two forks, which are stiffened by screwed rods. Within these forks there is carried a torque ring, the center of which is enclosed by cover plates, so as to form an oil reservoir. In the center of the oil reservoir there is a distribution box, which carries the spring-controlled inertia or dosing valves. As will be seen from the enlarged drawing to the right of Fig. 1, the inertia valve has a heavy head with a sharply tapering stem, which fits into a tapered inlet space surrounding the stems. The valve is held on its seat by a spring, and opposite to the spring there is a small air hole which keeps the casing open to the atmosphere, thereby preventing the formation of a vacuum in the oil distributing system. Whether the oil chamber is full or empty, oil finds its way into the tapered inlet leading to the valve seat, and, as the speed of the shaft increases, the oil so trapped opens the valve by its inertia effect, and a small quantity of lubricant is passed to the pins and bushes. The reservoir holds about half a pint of oil, and need only be replenished at intervals of three to four weeks. (*The Engineer*, vol. 152, no. 3958, Nov. 20, 1931, pp. 539–540, 2 figs., *d*)

PIPE

Metallic-Arc Method of Pipe Making

THIS is a description of the pipe-manufacturing plant of the South Durham Steel and Iron Co., Ltd., at its Stockton-on-Tees works. The plant is apparently one machine, and the article describes the manufacture of pipe 15 in. in diameter, 1/4 in. in wall thickness, and 25 ft in length. The plates for the manufacture of the pipe have their edges beveled. After planing, the plate is bent to a circle. Clamps are placed around to bring the edges together, and in this position the seam is tacked by a weld at intervals of approximately 2 ft.

The pipe then goes to the welding machine. This latter consists of two main girders of sufficient length to accommodate 30-ft pipes. The carriage for inserting or withdrawing the pipe is electrically driven, and a period of a few minutes only is required to set the pipe ready for welding or to withdraw it after welding.

The metallic-arc process is used, and the welding head is of the double type, i.e., with two welding units. The welding head travels along the rail track on top of the rail girders, and the travel motor is so arranged that it stops immediately the arc is broken. The two welding heads are used only when the thickness of the plate forming the pipe exceeds $^3/_8$ in.; for thinner plates only one head is used. Speeds of welding up to 45 ft per hr have already been obtained. The process is entirely automatic. (*The Iron and Coal Trades Review*, vol. 123, no. 3320, Oct. 16, 1931, pp. 573–574, *d*)

Flattening Tests of Electric-Resistance-Welded Steel Pipe

THE following quotation is taken from the tentative specification of the American Society for Testing Materials for this grade of pipe. This specification is designated as A 135–31T, and is published by the society for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision. The quotation is of interest in view of statements that have appeared to the effect that resistance-welded pipe is equal in strength and sometimes said to be stronger than the original skelp material.

"Both crop ends from each length of pipe shall be flattened between parallel plates with the weld at the point of maximum bending until opposite walls of the pipe meet. No opening in the weld shall take place until the distance between the plates is less than two-thirds of the original outside diameter of the pipe. No cracks or breaks in the metal elsewhere than in the weld shall occur until the distance between the plates is less than one-third of the original outside diameter of pipe, but in no case less than five times the thickness of the pipe wall. Evidence of lamination or burnt material shall not develop during the entire flattening process, and the weld, if fractured after crushing to less than two-thirds the original outside diameter of the pipe, shall not show injurious defects."

In this connection it is interesting to note that for soft-grade material the tensile strength and yield points are the same for skelp tests and pipe tests, though the elongation is higher for skelp than for pipe. In medium-grade steel the skelp test, yield point, and elongation in 2 in. are respectively for skelp 58,000, 33,000, and 30 per cent, and for pipe 60,000, 35,000, and 25 per cent, it being added that "if requested by the purchaser the tensile strength across the weld shall not be less than the minimum tensile strength of the grade of steel ordered." (*American Society for Testing Materials Tentative Standards*, pp. 92–97, *p*)

POWER-PLANT ENGINEERING (See also Marine Engineering: The Benson Marine Boiler)

Operating Characteristics of Overfeed Stokers

PROGRESS in the use of pulverized coal has not stopped the development of mechanical stokers, and in the last five years important refinements have been made to existing types and a number of new stokers have been introduced. Units are now available in power-operated types suitable for all coals and sizes and types of power and heating boilers having from 100 sq ft of heating surface up. The purpose of the article here abstracted is to describe the various types available and point out some of the operating features of the various units in each type.

Power-operated mechanical stokers are divided into three distinct types: overfeed; underfeed; and chain or traveling grate. The overfeed may be further classified as to natural or forced draft, front or side feed; as to the method of introducing the coal into the furnace—by air stream, revolving blades, or pusher blocks; and as to the type of grate employed—as standard horizontal or inclined shaking grate, reciprocating or power-driven grate bars, and special bars with directed air jets.

In units employing a revolving distributer and horizontal grate with forced draft but no agitation, the fuel-bed thickness is limited to around 3 in., while with the inclined type of grate employing reciprocating or movable grate bars the fuel-bed thickness can be increased to 6 in. or over. Certain types of overfeeds are also well suited to the burning of refuse fuels such as sawdust, hog fuel, etc.

The original article describes first a type of overfeed stoker designed to burn coals from $1^1/_2$-in. screenings down. In another stoker, the amount of coal supplied to the furnace by the revolving distributer used on the unit is regulated by changing the stroke of a reciprocating feedplate. The speed of the distributer is constant, and the spread of the coal is controlled by the setting of a circular tray forming the lower section of the distributer housing.

In another type the raising or lowering of a wedge by a steam-pressure regulator varies the stroke imparted to a pusher block. The revolving distributer is essentially an adjustable reel loosely fitted with four rows of cast-iron blades. The reel is formed by four blade shafts spaced 90 deg apart on a circle concentric to the main stoker shaft. Every other shaft has right-hand blades, and the alternate shafts have left-hand blades. On each shaft the angles of the blades vary so that each blade serves a particular area of the grate.

Maintaining a uniform fuel bed over the entire grate surface is one of the principal difficulties encountered with all types of stokers, especially where forced draft is employed. This difficulty is minimized, however, by proper preparation of the coal and by providing means to prevent segregation of the coarse and fine coal in the stoker hopper.

A unit has been designed especially to overcome this trouble by maintaining a compressed fuel bed. Two alternate movable grate sections having a reciprocating action slide on alternate stationary sections and push the fuel bed progressively toward the rear. The internal strength necessary in the fuel bed to overcome the frictional resistance of its weight on the grate surface tends to keep the fuel bed compressed in a compact mass of more or less uniform thickness. Natural or forced draft may be used.

Where a stoker must operate on a widely fluctuating load, or peaks must be met on short notice, forced draft is usually employed. Its use also permits of burning a wider range of fuels than is otherwise possible. The use of forced draft, however, calls for more careful attention on the part of the stoker operator, and if not properly handled may increase the stoker and refractory maintenance.

In many industrial plants the load can be carried for a large share of the time under natural-draft conditions, forced draft being used only over peaks or periods of increased load during certain hours of the day.

Some stokers are designed to permit ready change from forced- to natural-draft operation, as by removal of doors on the front of the stoker. (*Power*, vol. 74, no. 24, Dec. 15, 1931, pp. 858–860, 8 figs., *d*)

A Modern Lancashire Boiler Plant

THIS plant was installed by the London General Omnibus Company at Chiswick. It is designed for a range of eight boilers in two batteries of four each, but only one battery is in service. The boilers are each 8 ft 6 in. in diameter and 30 ft long, and are fitted with Bennis sprinkler stokers and self-cleaning air-draft furnaces arranged to take the air from an air heater at a temperature of 300 F. The preheated air is supplied from a Galloway supermiser. This supermiser (see MECHANICAL ENGINEERING, vol. 51, no. 3, Mar., 1929, p. 225) is placed behind the boilers in the position usually occupied by the ordinary economizer, although it can be placed also either above or alongside the boilers as it is not encased in brickwork flues.

The gases, after leaving the boiler, enter the main flue as is customary. From this they are drawn through the supermiser, entering at the top and leaving at the bottom by means of the induced-draft fan, the gases after passing through the fan being discharged to the chimney. In passing through the supermiser, the temperature of the gases is reduced to 250 F to 300 F, a much lower figure than that at which they leave the ordinary economizer. The fan is placed below the supermiser at the front end, and in this case is set at an angle to give satisfactory discharge to the chimney.

The air fan of this plant is placed below the supermiser and at the back end in order to give easy discharge. The air is drawn from the boiler house by the fan and forced through the supermiser, entering at the bottom and leaving at the top, from which it passes through an overhead duct, across the boilers, and down at the front into an underground hot-air duct carried across the front of the boilers.

Each boiler is provided with a number of instruments, of which the most interesting are the steam-pressure recorder and the combustion recorders. The former records the total amount of steam generated by all boilers on the line, and is equipped with a totalizer or integrator which automatically totalizes the rate of flow on a four-dial counter and indicates quite a number of things besides. The duplex mono-combustion recorder records the amount of any unburned gases. It is at all times a complete guide from the combustion point of view, and records at once incomplete combustion or the presence of unburned gases. A number of other instruments are used. The method of removing clinker and ash and the method of treating the boiler feedwater are explained in detail in the original article, and the details of a test showing 84.5 per cent efficiency are given in the form of curves. (*The Steam Engineer*, vol. 1, no. 1, Oct., 1931, pp. 15-17, 4 figs., *d*)

PRINTING

Fiske's Photo-Reduction Process of Printing Books

REAR-ADMIRAL FISKE, known for his invention of the aerial torpedo and other devices, is said to have developed a new method of printing books. In this method each page of the book is first typewritten, and then, by a photographic process, a zinc etching or printing plate one twenty-fifth of the original size of the page is made. A sufficient number of these etchings are then grouped together and printed on a single sheet for use in what the inventor calls a "reading machine."

This device consists, first, of a magnifying glass placed in proper relation to the above-mentioned printed sheet; and second, of an apparatus by which the reduced-size book pages—which are, of course, very small squares on the printed sheet—are brought in proper sequence into the field of vision of the magnifying glass, this being accomplished by a slight turn of a knob.

The process may prove of particular interest to engineers and scientists, as it would permit the cheap reproduction of works embodying involved mathematical formulas, tables, graphs, and illustrations. (Based on a description published in the *New York Tribune*, Dec. 15, 1931, but not further checked.)

RAILROAD ENGINEERING

Buenos Aires and Pacific Railway—Three-Cylinder Tank Engines

TWELVE large tank locomotives have recently been built for this railway by Robert Stephenson & Co., Ltd., Darlington, England. The paramount condition of the design was the capacity for rapid attainment of high speeds with heavy train loads. The boiler works at a pressure of 200 lb per sq in. and is of conventional design. The superheater header is of the Stirling type, incorporating a multiple regulator valve. The front cylinder and steam-chest covers are readily accessible, which has been made possible by the position of the inside steam chest. The inside valve gear has been specially designed to overcome the difficulties experienced when Walschaerts gear of normal type is applied to an inside cylinder. Three main difficulties encountered are:

1 The high location of the steam chest above the cylinder, necessarily close under, or with a limited boiler height actually obstructing, the lower portion of the smokebox, renders access at the front for inspection and withdrawal of the valve difficult.

2 The eccentric rod, often unavoidably short with an inside gear, has an undesirable degree of inclination, owing to the initial inclination of the valve gear, combined with a reversing link with little or no tail, this latter arising out of the desire to keep the throw of the eccentric within bounds. This inclination adversely affects the steam distribution, owing to the rise and fall of the engine on its springs.

3 The combination gear, i.e., lap and lead mechanism, must clear the leading axle. This, in some cases, gives rise to a very awkward problem, as provision must be made for the crosshead arm, with a connecting link of reasonable length, to reciprocate the entire length of the stroke either before, or behind, the axle. This condition may even influence the position of the crosshead and length of the connecting rod, or even of the axle itself.

The first and second of these difficulties can be entirely eliminated by placing the piston valve at one side of the cylinder, on or near the horizontal cylinder center line for standard- and broad-gage engines. In the case of narrow-gage engines some intermediate location must necessarily be chosen.

The third difficulty, however, remains, and is, if anything, intensified, for the downward projection of the crosshead arm is progressively increased as the valve and gear are brought down nearer to the horizontal. Further, the location of the piston valve to one side introduces a gap which is too wide to be adequately bridged by offsetting the crosshead arm, and would, with a normal Walschaerts gear, require either additional mechanism, such as cross-rocking lever or shafts, or a radical modification of the design of the motion.

In the valve gear under review, these difficulties have been entirely overcome by swinging over the combination gear to suit the piston valve, thus bridging the gap by means of members of the normal Walschaerts gear itself. Thus, the essential simplicity of this motion is retained, without the introduction of additional wearing parts in the line of thrust. In fact, we

understand that but one extra joint is necessitated by the new gear.

Among the other interesting features may be mentioned the provision of steel Kinnear roller shutters at the cab sides. They are intended to serve as a protection against the invasion of locusts and the like. Steam brakes operate all the wheels of the engine, including the bogies. (*The Engineer*, vol. 152, no. 3960, Dec. 4, 1931, pp. 601–602, 3 figs. and one plate, *d*)

TESTING AND MEASUREMENTS

Fine Testing Sieves

IN THE August, 1931, issue of MECHANICAL ENGINEERING, p. 616, there appeared a résumé of an article by P. E. Masters in *Engineering* for May 22 last. Reference was there made to some of the work of the Bureau of Standards, and this caused the publication in a later issue of *Engineering* of a letter from L. V. Judson, Chief, Length Section, U. S. Bureau of Standards. The present article is intended to call attention to this letter and abstract some of its parts.

The British standard specifications for test sieves (410-1931) contains three series of sieves, of which only the fine series will be considered here. The tolerances in maximum openings are grouped in the same way as those of the Bureau of Standards, as shown by a list in the original article. The British do not have a definite tolerance for wire diameter, but state that "the wires used shall be of circular cross-section and shall conform in size as nearly as possible to the diameter specified." This is criticized by Mr. Judson, who says that if a strict interpretation were to be placed on this part of the specification, it would seem that many sieves might be rejected for excessive variation in wire diameter, which would give practically identical sieve results as sieves which were exactly nominal.

Although it is stated in the foreword of the specification that the series of fine-mesh sieves is based on a ratio of the fourth root of two between linear-aperture measurements of consecutive series, Mr. Judson indicates noticeable deviations from this law, which he believes were made so as to specify the opening which would result from using wire of exact gage number woven with an integral number of wires per inch, a procedure which he criticizes.

The wire diameters of the British specifications differ from those specified by the Bureau of Standards for two reasons, which Mr. Judson specifies. Although the British and American series of sieves are very similar and in some respects identical, there is a difference in viewpoint. The idea at the Bureau of Standards in preparing its specifications was that a series of numerical dimensions of wire diameters and openings should be set up which would be as nearly ideal as could be prepared, and then to provide tolerances liberal enough to permit the certification of carefully made sieves constructed by different manufacturers and giving satisfactory sieving results.

Mr. Judson shows why the procedure of using different meshes with different wire diameters so as to produce a given aperture is not unsound, and objects to a statement by Mr. Masters that "the U. S. Bureau of Standards table is a theoretical one which does not allow of practical application." The table is indeed a theoretical one, but it does allow of immediate practical application, as shown by an example in the original letter. As a matter of fact, nearly 5000 sieves have been certified by the Bureau of Standards as conforming to the specifications of the U. S. standard sieve series.

The Bureau of Standards decided upon the use of arbitrary numbers for designating sieves, as designation by mesh was considered a potential source of trouble. The micron designation for sieves adopted by the American Society for Testing Materials has the personal approval of Mr. Judson, but the subject is expected to receive further consideration in the Bureau of Standards. (L. V. Judson, Bureau of Standards, in a letter in *Engineering*, vol. 132, no. 3434, Nov. 6, 1931, p. 590, *p*)

THERMODYNAMICS

A New Equation of State for Water Vapor

OUR knowledge of molecular physics, the kinetic theory of gases, statistical mechanics, and the quantum theory is not yet sufficiently extensive to permit the formation of an equation of state based on pure theory but capable of presenting with sufficient precision the actual behavior of gases and vapors. In the matter of water vapor the case is unsatisfactory, as we have to deal here with deviations from the ideal gaseous state, not only due to the attraction forces acting between the molecules, but very likely also to the formation of duplex, and quite possibly multiplex, molecules. The assumption that water vapor with increasing pressure contains an increasing number of duplex molecules is in the first place supported by the fact that ice consists entirely or at least predominantly of duplex molecules, as shown both by the calculation by quantum-theory methods of its specific heat as well as by X-ray analysis of its structure. Furthermore the increase in the specific heat of superheated steam with increase in pressure and decrease in temperature in the neighborhood of the saturation line is so great that it can only with difficulty be explained by the action of van der Waals' cohesion forces and co-volume. All that we have been able to do hitherto has been to express theoretically, so that it would be in accordance with experience, the terminal state into which superheated steam passes with constantly decreasing pressure and in which only simple molecules are present. This is due to the fact that at pressure $p = 0$, not only pv assumes the value RT derived from the kinetic theory of gases, but, as is shown in the present investigation, the specific heat c_{p0} is satisfactorily expressed by a calculation based on the quantum theory. The fact established by this, namely, that the vibrations of the atoms within the H_2O molecule contribute a certain amount toward the increase of the internal energy of the water vapor, is a further difficulty in the way of the theory of the equation of state, as this amount even where only simple H_2O molecules are present, is a function of the pressure and is particularly strongly affected as a result of the building up of duplex molecules. All this would indicate that we shall have to go a very long way before we can produce a theoretically satisfactory equation of state, and that in the meantime the only thing we can do is to use empirical equations of state. Furthermore a theoretical equation of state would probably be too complicated to permit practical calculations of the magnitudes desired.

As a basis for the establishment of a precise empirical equation of state the measurements of the specific heat c_p of superheated water vapor are particularly suitable as their dependence on the pressure gives a sensitive criterion of the deviations from the ideal gaseous state. Very precise tests have been carried out in the Laboratory for Technical Physics of the Munich Technical Institute by Knoblauch and his collaborators, and recently these measurements have been extended by Knoblauch and Koch up to a pressure of 120 atm. In this case it is intended by extrapolation to cover the region of higher pressures up to 250 atm.

Quantum Theoretical Computation of c_{p0}. The quantum theoretical calculation of the energy of the intramolecular oscillations within the triatomic molecule of water leads to the following equation for specific heat c_{p0} for a pressure $p = 0$.

$$c_{p0} = 4AR + AR\,\frac{\left(\frac{\theta_1}{T}\right)^2 \times e^{\frac{\theta_1}{T}}}{\left(e^{\frac{\theta_1}{T}} - 1\right)^2} + 2AR \times \frac{\left(\frac{\theta_2}{T}\right)^2 e^{\frac{\theta_2}{T}}}{\left(e^{\frac{\theta_2}{T}} - 1\right)^2} \quad \ldots [1]$$

where $R = 47.053$ mkg per kg per deg C, being the gas constant for 1 kg of water vapor; $A = 1/426.9$, being the mechanical equivalent of heat, and the so-called characteristic temperatures θ_1 and θ_2 are abbreviations for hv_1/k and hv_2/k, where h is the Planck quantum number, v_1 and v_2 are the frequency numbers, and k is the gas constant for one molecule. According to Wohl and von Elbe, $\theta_1 = 2280$ and $\theta_2 = 5370$. According to the kinetic theory of gases the first member of the right-hand side of Equation [1] corresponds to the calculated transitional and rotational energy of the molecule. The second member then represents the amount due to the slow oscillations of the oxygen atom, and the third member the more rapid atomic oscillations.

A comparison with the c_{p0} values obtained by the extrapolation of the c_p measurements of Knoblauch and his collaborators for the pressure $p = 0$ has shown that Equation [1] gives values in close correspondence therewith within the limits of experimental error. On the average the curve calculated

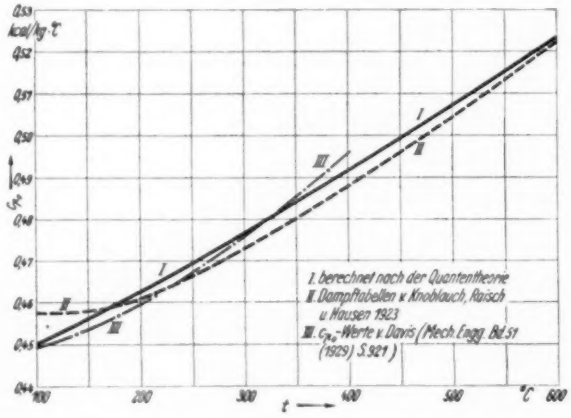

FIG. 2 SPECIFIC HEAT c_{p0} OF SUPERHEATED WATER VAPOR AT INFINITELY SMALL PRESSURE

(I, Calculated in accordance with the quantum theory; II, Steam tables of Knoblauch, Raisch, and Hausen, 1923; III, Values as determined by Davis, MECHANICAL ENGINEERING, vol. 51, 1929, p. 921.)

from Equation [1] gives the extrapolated values at least as well as the c_{p0} curve of Fig. 2 adopted in the steam tables of 1923.

Fig. 2 shows further that the values of c_{p0} indirectly derived by Davis (Harvey N. Davis and Joseph H. Keenan, MECHANICAL ENGINEERING, vol. 51, 1929, p. 921) from observations of the Thomson-Joule effect and lying at the foundation of the American steam tables, come very close to the curve calculated from the quantum theory. It therefore appeared justifiable to use Equation [1] for the calculation of the new steam tables. (In the second edition of the Steam Tables is given an empirical equation for c_{p0} more convenient for purposes of calculation and giving for the region from 0 C to 600 C the same values as Equation [1]).

Empirical Equation for c_p *and* c_{p0}. An empirical equation which properly indicates the course of variation of measured magnitudes and which may be used as a foundation of thermodynamic calculations, in addition to being of sufficient precision and convenience in handling must also satisfy the condition of being convenient for numerical calculations and be susceptible to differentiation and integration without excessive difficulty. An empirical equation satisfying the above conditions can be found only by the method of trial—for example, by plotting a given function graphically and by varying known analytical functions showing a similar method of variation, until a sufficient agreement with the plotted curve is obtained. The constants of the equation can only be approximately determined by this method of trial, and may be later so determined by additional calculation as to give the best reproduction of experimental values in accordance with the method of least squares.

In the present case in which the function to be established is one depending on two variables p and t, the specific heat c_p is first plotted as a function of pressure p for various constant values of temperature t (Fig. 3). The first step is to try at

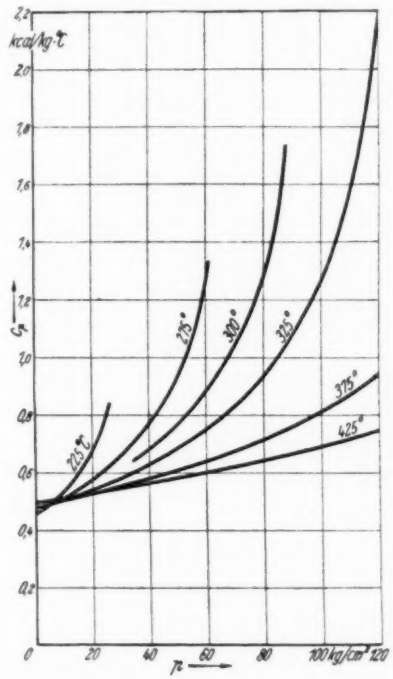

FIG. 3 SPECIFIC HEATS c_p OF SUPERHEATED WATER VAPOR

(These are isotherms obtained by graphical evaluation of the experimental data of Knoblauch and Koch.)

325 deg, where the curve changes most and shows a certain similarity to a parabolic arc, the equation $c_p - c_{p0} = \alpha \times P^m$ with constant values for α and m, and with P expressed in kilograms per square meter. This equation is not satisfactory and it is only the three-member potential series

$$c_p - c_{p0} = a_1 \times P^{m1} + a_2 \times P^{m2} + a_3 \times P^{m3}$$

that gives a satisfactory expression for this curve. The curves at 225, 275, 300, 375, and 425 C can be also expressed by this equation, provided one retains the values of m_1, m_2, and m_3 and inserts correspondingly modified values of a_1, a_2, and a_3. These values of a_1, a_2, and a_3 are established approximately in accordance with their functional dependence on the tem-

perature, and in order to determine whether these values can be considered as simple powers of the absolute temperature T, the logarithms of a_1, a_2, and a_3 are plotted as functions of log T. Since this gives approximately straight lines inclined downward and to the right, by employing the following three new constants A_1, A_2, and A_3 we can set

$$a_1 = A_1\left(\frac{1}{T}\right)^{n_1};\quad a_2 = A_2\left(\frac{1}{T}\right)^{n_2};\quad a_3 = A_3\left(\frac{1}{T}\right)^{n_3}$$

and therefore

$$c_p - c_{p0} = A_1\frac{P^{m_1}}{T^{n_1}} + A_2\frac{P^{m_2}}{T^{n_2}} + A_3\frac{P^{m_3}}{T^{n_3}}$$

The next problem is to obtain more convenient numerical expressions for the coefficients. This introduces two new sets of values which must be so determined as to permit the equation obtained thereby to express the experimental values as closely as possible by means of the method of least squares. The calculation which follows is very complicated and cannot be reproduced here because of lack of space. It shows, however, how an equation may be obtained by the trial method. The values of the constants are determined by the application of the theory of determinants, and their numerical values are given in the original article. From this the author proceeds to the establishment of equations for the specific volume v, heat content i, and entropy s. This leads him to the employment of certain functions of the pressure, for which he finds expressions. The equation for c_p is given as

$$c_p = c_{p0} + C_1\left(\frac{P}{P_k}\right)^{m_1}\left(\frac{T_k}{T}\right)^{n_1} + C_2\left(\frac{P}{P_k}\right)^{m_2}\left(\frac{T_k}{T}\right)^{n_2} + C_3\left(\frac{P}{P_k}\right)^{m_3}\left(\frac{T_k}{T}\right)^{n_3} \quad \ldots\ldots [2]$$

and the values of the constants are given in the original article as follows:

$$\left.\begin{array}{l} C_1 = 0.5311;\ m_1 = 1;\ n_1 = 3.5 \\ C_2 = 1.1991;\ m_2 = 3;\ n_2 = 18 \\ C_3 = 8.3054;\ m_3 = 12;\ n_3 = 60 \end{array}\right\} \quad \ldots\ldots [3]$$

for $P_k = 225.05 \times 10^4$ kg per sq m and $T_k = 647.2$ C abs.

From Equation [2] the author derives—by certain substitutions which cannot be reported here because of lack of space—the following expressions for specific volume v, heat content i, and entropy s:

$$v = \frac{RT}{P} - \frac{T_k}{AP_k}\left[\frac{m_1C_1}{n_1(n_1-1)}\left(\frac{P}{P_k}\right)^{m_1-1}\left(\frac{T_k}{T}\right)^{n_1-1} + \frac{m_2C_2}{n_2(n_2-1)}\left(\frac{P}{P_k}\right)^{m_2-1}\left(\frac{T_k}{T}\right)^{n_2-1} + \frac{m_3C_3}{n_3(n_3-1)}\left(\frac{P}{P_k}\right)^{m_3-1}\left(\frac{T_k}{T}\right)^{n_3-1}\right] + f_1(P) + Tf_2(P) \quad \ldots [4]$$

$$i = \int c_{p0}\,dT - T_k\left[\frac{C_1}{n_1-1}\left(\frac{P}{P_k}\right)^{m_1-1}\left(\frac{T_k}{T}\right)^{n_1-1} + \frac{C_2}{n_2-1}\left(\frac{P}{P_k}\right)^{m_2-1}\left(\frac{T_k}{T}\right)^{n_2-1} + \frac{C_3}{n_3-1}\left(\frac{P}{P_k}\right)^{m_3-1}\left(\frac{T_k}{T}\right)^{n_3-1}\right] + A\int f_1(P)dP \quad \ldots [5]$$

$$s = \int \frac{c_{p0}}{T}\,dT - AR\log_e P - \frac{C_1}{n_1}\left(\frac{P}{P_k}\right)^{m_1}\left(\frac{T_k}{T}\right)^{n_1} - \frac{C_2}{n_2}\left(\frac{P}{P_k}\right)^{m_2}\left(\frac{T_k}{T}\right)^{n_2} - \frac{C_3}{n_3}\left(\frac{P}{P_k}\right)^{m_3}\left(\frac{T_k}{T}\right)^{n_3} - A\int f_2(P)dP \quad \ldots\ldots [6]$$

In Equation [4] there are functions $f_1(P)$ and $\varphi(P) = \frac{R}{P} + f_2(P)$ which appear after double integration and may be selected at will. In this case the part of the pressure function $\varphi(P)$ is so selected that for an infinitely small pressure, Equation [4] becomes $v = RT/P$. These functions can only be determined experimentally. Some details as to the method of their determination are given in the original article, which also gives the following values for them:

$$f_1(P) = 0.01148\left(\frac{P}{P_k + P}\right)^2 \quad \ldots\ldots [7]$$

$$10^4 \times f_2(P) = 0.0233 - \frac{0.0652}{10^{-4}P + 1} - 0.1520\left(\frac{P_k}{P_k + P}\right)^2 \quad \ldots [8]$$

The remainder of the article deals with the matter of extrapolation and a comparison of the data obtained here with those of the Second International Steam Tables Conference in Berlin. (H. Hausen, Munich, in *Forschung auf dem Gebiete des Ingenieurwesens*, vol. 2, no. 9A, Sept., 1931, pp. 319–326, *mtA*)

WELDING (See also Pipe: Metallic-Arc Method of Pipe Making; Flattening Tests of Electric-Resistance-Welded Steel Pipe)

Machine Gas Cutting of Heavy Plate

IN THE past heavy plate could only be sheared mechanically in straight lines, and then had the usual flat condition characteristic of all sheared material. Today the cutting can be done with oxygen not only in straight lines but also in a curved or irregular direction, with the cut edge either vertical or beveled and without the usual shear distortion. The progress in heavy cutting has created in the steel industry a demand for heavy material to be used as machine parts or in high-pressure vessels where elevated temperatures must be withstood.

The original article mentions the question of wages and bonuses to cutters, and then proceeds to a discussion of the effect of gas cutting on the material cut. Microscopic inspection shows that the cut edge is materially different from the original metal.

One of the points of difference has been the change of pearlitic steel into an unstable condition, such as sorbitic, troostitic, or martensitic, depending on the amount of carbon present in the steel and the speed with which the metal is cooled. Another interesting change is the tremendous grain growth which occurs on the gas-cut edge, the grain side gradually tapering back to the normal in the original metal. It has been also discovered that the carbon content is increased on the burned edges. Results of such investigations as have been made indicate that the increase in the carbon on the outside cut edge cannot be attributed to the carbon in the acetylene, and it would appear that it is due to the migration of the carbon toward the edge. These physical and chemical changes

in the steel leave a thin hardened zone on the outside edge, the penetration of which is usually superficial. This depth of penetration of the altered zone has been found to have a definite relation to the thickness of the material cut. Furthermore, hot cutting is beneficial to the steel and is also economical in the use of oxygen. Steel slabs up to 30 in. thick can be cut. (L. M. Curtiss, Lukens Steel Co., Coatesville, Pa., in *Steel*, vol. 89, no. 27, Nov. 16, 1931, pp. 31–33 and 38, *d*. Compare *American Machinist*, vol. 75, no. 21, Nov. 19, 1931, pp. 784–785, 4 figs.)

Welderies

CUTTING and welding are the principal fabricating processes in a number of shops of a new type for the manufacture of beds, frames, and other machinery parts. These shops are known as "welderies." At the recent meeting of the American Institute of Steel Construction it was stated that an exhaustive study reveals a potential consumption of rolled steel for these purposes amounting to 4,000,000 tons a year. The steel companies have begun to take interest in welderies. Today one steel company is directly interested in the new industry, and a half-dozen others are studying it closely. (Editorial in *Steel*, vol. 89, no. 21, Nov. 16, 1931, p. 26, *g*)

VARIA

Timed Public Works a Fallacy

THE author, who is associate professor of economics at Lehigh University, Bethlehem, Pa., does not believe in the scheme of curtailing and postponing public construction during periods of prosperity so that it may be used to take up the slack in employment during periods of depression. He believes that the success or failure of the scheme depends upon the ability of timed public construction to check business expansion, and tries to show that if the plan were put into operation, expansion would be encouraged during the next period of prosperity instead of discouraged.

It is in examining the financial aspect of the plan that he claims its unsoundness becomes apparent.

As public works can be paid for only by taxes (i.e., irrespective of the immediate method of raising the funds), the collection of taxes for the purpose of accumulating public-works reserve funds would amount to an annual transfer of purchasing power from private purses to the public treasuries, which would, however, deposit the money in banks and thus provide credit for expansion in prosperous years. This increasing supply of capital, available at low interest rates, would not long remain unemployed.

The effect of financing the postponed improvements by borrowing would be similar to those of the reserve-fund methods of financing just referred to. The conclusion to which the author comes is that timed public construction would magnify the depression, and the larger the volume of public works postponed, the greater the slack in employment to be taken up during depression. To check industrial expansion during the upswing of the cycle by postponing public construction, it would be necessary for the labor and capital so released to be made unavailable to industry. But this would create unemployment of labor and capital at one time merely for the sake of employing them at another, and the only way to equalize employment by regulating construction would be to regulate and time *all* construction, both private and public, which would hardly receive general approval. (Ward L. Bishop, in *Engineering News-Record*, vol. 107, no. 25, Dec. 17, 1931, pp. 965–967, *g*)

Decision of the U. S. Supreme Court in the Permutit Patent Case

THIS case has come to the U. S. Supreme Court on a writ of certiorari which has been issued because two Circuit Courts of Appeals have been found to be in conflict.

The decision was that in the Gans patent No. 1,195,923 for an apparatus for softening water by the use of artificial zeolites, claims 1 and 5 are invalid. The most interesting part of this decision is that referring to the invalidation of a claim by lack of disclosure. This case hinged on the employment of a "free" bed of zeolites as against a "locked" bed, and the discovery that a rise in space above the zeolite bed is necessary for the successful operation of the softener. The Court found that neither of the claims involved in the litigation makes mention of a "free" zeolite bed, and proceeds as follows:

"As the patentee has thus failed to give in the specification 'a written description' and has likewise failed particularly to point out and distinctly claim the free zeolite bed, as 'the part, improvement, or combination which he claims as his invention or discovery,' the patent is void.

"The question of compliance with the requirement of disclosure laid down by Section 4888 was not adverted to in either opinion of the Second Circuit Court of Appeals sustaining the validity of the patent, 279 Fed. 713 22F (2d) 916, nor was it called to the attention of this court, which denied certiorari in the first case in 259 U.S. 588.

"Both district courts in those cases seem to have thought that the free surface of the zeolites was indicated by the attached drawing, and to have deemed that sufficient, although nowhere mentioned in the description or claims, 274 Fed. 937, 942; 292 Fed. 239, 240.

"The opinion in the second case added that this feature was necessarily 'presupposed' in the stirring device mentioned in the description as 'advantageous' and included in other claims not now in suit, and it was 'involved' in the absence from claims 1 and 5 of any upper sand filter.

"These conclusions were adopted by the Circuit Court of Appeals for the Sixth Circuit, which invoked the doctrine that 'if the specification and drawings of a patent show a structure clearly involving a certain theory of operation, it is not necessary that the patentee should expressly describe this theory, nor indeed that he should at that time clearly understand it.'

"We think that these views rest upon misconception. The absence in the claims of a sand bed placed above the zeolites does not imply that the zeolite bed is to be unconfined. The only normal inference from such silence is either that it was deemed immaterial whether the zeolite bed be locked or free, or that if a free bed is preferable, it was not claimed because it lacked novelty.

"The drawing annexed to the specification, it is true, shows a layer of sand or quartz at a point above the zeolites and an unoccupied space between it and the top of the zeolite bed. But there is no suggestion on the drawing or elsewhere that the upper plate bearing the layer of sand or quartz has any purpose except to serve as a mechanical filter through which 'the water to be softened may be first filtered,' or that the unoccupied space has any other purpose than that of similar spaces in sand filters long familiar.

"Moreover, while drawings may be referred to for illustration and may be used as an aid in interpreting the specification or claim, they are of no avail where there is an entire absence of description of the alleged invention or a failure to claim it.

"The statute requires the patentee not only to explain the principle of his apparatus and to describe it in such terms that any person skilled in the art to which it appertains may con-

struct and use it after the expiration of the patent, but also to inform the public during the life of the patent of the limits of the monopoly asserted, so that it may be known which features may be safely used or manufactured without a license and which may not." (Abstracted from decision as published in the *United States Daily*, Nov. 25, 1931, *g*)

Patent Office Procedure Shown as Aid in Unemployment Situation

FURTHERANCE by the Patent Office of Federal unemployment relief measures by granting priority to patents which give promise of resulting in more jobs at an early date is revealed in the annual report of Patent Commissioner T. E. Robertson.

Before special consideration is given to a patent application, Commissioner Robertson points out, the applicant must agree to expend a certain amount of capital in the manufacture of the article patented. Furthermore, advancement in the order of examination is made only when a pledge is given that three months after the allowance of the application a report will be submitted to the Patent Office showing such details as the amount expended in manufacturing the article, the actual number of units made, and the extent to which such manufacture has increased the employment of labor.

During the last fiscal year, Commissioner Robertson reports, approximately 300 patent applications were treated as "special" and granted priority in examination. The practice of compelling sworn returns in connection with these special cases, he points out, has not been in operation long enough for his office to obtain complete information on results. However, returns already received indicate that a substantial number of workers were given employment last year in connection with the manufacture of articles covered in the special cases. (From a release of the Department of Commerce, Washington, D. C., of part of the Annual Report of the Commissioner of Patents, *g*)

Engineering Pioneering

THE whole of modern material civilization rests in a sense ultimately on the application of scientific knowledge, but that application has usually not been made by scientists and has frequently not even been explained by them until after its practicability has been demonstrated by engineers. As instances are cited water purification, compressed-air diseases in tunnel work, wireless telegraphy, and use of steam at high pressures and temperatures. Even in regard to chemical manufacture, it is the engineer who in general has to bridge the gap between the laboratory experiment and commercial success.

In connection with power generation, the remarkable boiler efficiencies now attained have been almost exclusively due to the engineer. The chemist could tell him what proportion of CO_2 corresponded to perfect combustion without excess of air, but not how closely this limit could be approached. The introduction of pulverized-fuel firing is again to be attributed to the engineer, and involved many costly experiments, of which by no means all were successful. It is true that Bettington seems, by instinct, to have hit at the very outset upon the general principles which should govern the design of pulverized-fuel plant, but owing to his early death in the Great War, these had largely to be rediscovered by his successors. Further, those who, 30 years ago, attempted to design steam turbines of their own had many a disastrous experience. In the case, for example, of a large marine turbine built in Germany during these early days, the shaft welded itself to the diaphragms, and it took days of work to clear the wreck. The makers also of one of the most successful of the earlier impulse steam turbines had so many cases of stripped blades that they admitted, confidentially, that their profits almost disappeared in making matters good. At a later date most turbine builders had troubles from disk vibration, for which the engineer had to find both the cause and the cure, while today he is, as already noted, confronted with great difficulties owing to the tendency of the materials available to "creep" at high temperatures.

The fact is that engineering is not a science but essentially an art which is distinguished by the use it makes of mathematics and science. The engineer's first objective is to make things work and his second is to make them foolproof, which is sometimes the more arduous task of the two. The best engineers have even a fair claim to be considered as artists. (Editorial in *Engineering*, vol. 132, no. 3438, Dec. 4, 1931, pp. 703–704, *g*)

Bright Annealing of Metals With Hydrocarbon Gases

THE problem is essentially a chemical one. The energy of formation of oxides decreases as the electromotive series is descended. For these reasons some metals may be maintained bright very easily during heat treatment, the only requirement being that no free oxygen shall be present in the atmosphere. This is generally accomplished by using raw all the products of combustion in a muffled furnace, and in some cases steam is employed.

Other metals are much more difficult to heat treat, for example, copper-zinc alloys (brass). At low temperatures the difficulties encountered are not great, but as the temperature is increased to the point where zinc begins to volatilize from the surface, the difficulties are multiplied.

The volatilization of zinc seems to be coincident with the liberation of occluded gases. These gases are oxidizing to the metal and result in the formation of a scale on the surface of the metal, consisting either of zinc oxide or a mixture of oxides. Thus the metal becomes tarnished and the problem of bright annealing is greatly complicated.

Recently a process for the bright annealing of metals has been developed which is applicable to industry. Apparently any gas which is not deleterious to the metal, and which will serve as a source of hydrogen may be employed. Pure hydrogen itself may be used, but it has certain severe limitations. Not only is its explosibility a drawback, but its use increases the volatility of zinc when the metal being annealed is brass. Comparative tests indicated that there was a loss of 1.8 per cent of the weight of brass sheets when annealed in a hydrogen atmosphere, as compared with 0.7 per cent when the annealing atmosphere was methanol and flue gases.

Apparently hydrocarbon gases will prove the cheapest and most available raw material for this bright-annealing process. With their use it is possible to produce the desired amount of hydrogen under suitably controlled conditions. (E. G. de-Coriolis and R. J. Cowan, Surface Combustion Corp., Toledo, O., in *Industrial and Engineering Chemistry*, vol. 24, No. 1, Jan., 1932, pp. 18–20, 2 figs., *d*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

SYNOPSES OF A.S.M.E. PAPERS

THE papers abstracted on this and following pages appear in the current issues of the Aeronautics, Applied Mechanics, Machine-Shop Practice, Management, and Wood Industries sections of A.S.M.E. Transactions. These sections have been sent to all who registered in the similarly named Divisions. Other sections are in the course of preparation and will be announced, when completed, in later issues of "Mechanical Engineering." Copies of these papers may be obtained by addressing the Secretary of the A.S.M.E., 29 West 39th Street, New York, N. Y.

AERONAUTICS

Airplane-Cabin Engineering

THE intense interest taken in the development of the interior design of the airplane is the national consequence of the competition between the airplane, the Pullman car, the automobile, and the motor bus for the patronage of the general public.

While essentially a problem of the decorator, interior design demands the whole-hearted cooperation of the aeronautical engineer. It must be always in mind from the inception of the structural design, so that the maximum opportunity for eye appeal is assured the decorator. Wall, ceiling, and floor treatments, hardware, sanitary equipment, accessories, chairs, windows, doors, soundproofing, and fireproofing, all are within the scope of interior design. All must be blended into a harmonious whole, keeping ever in the forefront of the design the fundamental aeronautical requirements of minimum weight and maximum space utilization. (Paper No. AER-53-14, by Pierre Freyss and John F. Hardecker.)

Airplane-Wing Trussing

THIS paper compares and analyzes the existing types of wing bracing in conventional airplanes. The internal structure of airplane wings is closely linked with the external system of support, and therefore the paper covers some of the methods of internal bracing, but is mainly devoted to systems of external bracing. The efficiency of the wing trussing is a function of the size of the machine. For a low-wing design the wire-braced wing seems quite efficient, provided the span is not too great compared with the height of the plane. For a larger span, subject to high wing loadings, the high-wing monoplane is very efficient, though there are many points in favor of both the braced and the cantilever wing. For the very large plane, with a normal fuselage, the biplane bracing is advantageous. On large designs where a part of the load can be carried in the wings, the monoplane is better aerodynamically. (Paper No. AER-53-15, by Richard M. Mock.)

Design and Development of Seaplanes for Transatlantic Service

THE author takes up in succession the various problems involved in the design and construction of a multi-engined airplane capable of making a transoceanic non-stop flight of 5000 miles and carrying a pay load of 21 tons. Among the topics dealt with are: Location of engines and propellers; influence of load distribution on weight of wing structure; aerodynamical researches of the Göttingen laboratory on a model of the author's plane; hydrodynamical starting tests in tank at the Hamburg Shipbuilding Research Institute; influence of various factors on size of pay load; maximum power outputs from oversize engines at various altitudes; necessity of greatly increased airplane speeds; etc. (Paper No. AER-53-16, by Dr. E. Rumpler.)

Some Aspects of the Seaplane

AFTER a brief historical résumé, the author deals, respectively, with the efficiency of the seaplane, constructional features, design of floats and boats, engine arrangement, beam load, seaworthiness, service questions, official requirements to be met, etc. Many tables, charts, and illustrations are included, and the subject is treated with special respect to developments in Germany. (Paper No. AER-53-17, by Frederick P. Schuettel.)

Sheet-Metal Airplane Construction

ONE of the first successful attempts to manufacture all-metal planes in Germany was made by the airplane branch of the Zeppelin Works at Lindau. Entirely new principles of construction were applied in Professor Junkers' "Iron-Monoplane" built in 1915. Up to that year the covering of airplane wings served essentially the sole purpose of giving them a certain shape and of providing a surface for maintaining the supporting air pressure. The distribution of the stresses was assigned to a special supporting structure which also included the external wiring and struts. Junkers made the external fairing of the wings of metal, and at the same time combined it with the internal supporting structure so as to form a strong integral supporting body. Thus the increase of weight of the fairing as compared with a cloth covering was at least partially saved in the internal structure.

These principles prepared the way for the development of all-metal planes in Germany, and in the course of years various forms and types of such supporting fairings have been developed. The use of sheet-metal fairing for support is the outstanding constructional characteristic of such structures, and this paper discusses at length the possibilities of building such sheet-metal walls. (Paper No. AER-53-18, by Prof. Dr. Ing. Herbert Wagner.)

APPLIED MECHANICS

Forced Vibrations With Combined Coulomb and Viscous Friction

STEADY-STATE vibrations of mechanical systems damped by a combination of dry and viscous friction occur quite frequently, but until very recently no method for their calculation existed. A very satisfactory approximation was presented by L. S. Jacobsen before the A.S.M.E. in June, 1930. In the present paper the author gives the exact solution of the problem, together with a number of test results. (Paper No. APM-53-9, by J. P. Den Hartog.)

Strength of Materials Subjected to Shear at High Temperatures

THIS paper treats of an experimental program which is basically fundamental in the study of creep. Uniformly pure shear is produced in a thin tubular specimen submitted to twist, whereas the usual method employs a solid bar in tension. This torsion form of test permits greater accuracy in the measurement of creep and provides the simplest stress condition, besides offering other decided advantages.

Since this work in twist represents virtually a pioneer attack, it has been necessary to develop practically from the beginning each phase of the investigation. The type of specimen, apparatus for the creep tests, including the measuring instruments, and experimental technique are described.

The experiments have been of three kinds: (1) Room-temperature tests were first made to determine the usual physical properties in torsion and in tension; (2) at various temperatures short-duration tests were made to learn the effect of different rates of loading, the modulus of elasticity in shear, and the ultimate strength in shear; (3) at 400 C and 500 C several creep tests in shear of relatively long duration were conducted. An accelerated method of making creep tests has been devised. In addition several special problems were investigated such as a study of the increase of the yield point by creep and the restoration of the original yield point by annealing, the effect of vibrations, which included a continuous record of creep, and the effect of temperature fluctuations. (Paper No. APM-53-10, by Franklin L. Everett.)

Recent Advances in Photoelasticity

AFTER discussing the principle of optical equivalence of stressed isotropic bodies, the author deals respectively with current methods to determine $(P - Q)$; the fringe method; annealing of bakelite; fringe photographs of various models; membrane method to determine $(P - Q)$; the photoelastic investigation of stress distribution in square plates subjected to diagonal compression; isoclinics; trajectories; $(P - Q)$ from fringe method; and P and Q by graphical integration. He then summarizes the approximate theoretical analysis by the strain-energy method, gives comparative curves, discusses results, describes new equipment, and in conclusion, derives fundamental equations for the evaluation of P and Q by graphical integration. (Paper No. APM-53-11, by Max M. Frocht.)

Influence of Damping in the Elastic Mounting of Vibrating Machines

THIS paper considers the elastic material for, and design of, elastic mountings intended for the prevention of transmission of vibration from electrical apparatus into the structure of buildings in which comparative quiet is desired. The effectiveness of such a support depends on the square of the ratio of the frequency of the impressed disturbance to the natural frequency of the machine on its mounting. Thus the natural frequency of the machine on its mounting must be made low in comparison with the impressed frequency. It is shown analytically that damping, or internal friction, in an elastic mounting causes additional transmission through the mounting. An apparatus was built to compare directly the effectiveness of materials proposed for elastic support. The detrimental effect of damping is clearly shown at high ratios of impressed frequency to natural frequency, causing the transmission to be doubled in the case of some samples. Therefore when choosing the elastic material for a support it is necessary to consider the damping present in the substance. Drift tests were also made to aid in determining the best material for this work. In several ways rubber appears to be well suited to use as an elastic support material. As an example, its incorporation in a mounting for a 15-hp induction motor is described. (Paper No. APM-53-12, by E. H. Hull.)

Thermal Stresses in Thin-Walled Cylinders

THE author, using Föppl's method, investigates the stresses in (1) a cast-iron cylinder 30 in. long, 20 in. mean diameter, and 1 in. in wall thickness, with the temperature 100 F higher inside than outside; (2) the same cylinder and temperature conditions, but with cylinder supported at the ends; and (3) a steel cylinder of the same size with flat heads rigidly attached and subjected to 500 lb per sq in. internal pressure. Constant and variable temperature gradients are considered, both in axial and radial directions. (Paper No. APM-53-13, by Clarence H. Kent.)

Jets From Manifold Tubes

AFTER a brief reference to previous work on the subject, the author develops an expression for the discharge coefficient. He then determines the flow of a sheet of water through a slot of infinitesimal width in the wall of a pipe by means of a variable and a constant discharge coefficient. The slot is then conceived of as a row of separate holes and the flow problem is solved by means of difference equations for a variable and a constant discharge coefficient. A special case is also considered in which the pipe has a hole through its further (closed) end. (Paper No. APM-53-14, by Jacob Kunz.)

The Yield Point of Mild Steel

THIS paper is a review of some of the more important investigations made concerning the yield point, together with the effect of certain conditions on the yielding of mild steel. Recent investigations concerning the yield point are also described. The pronounced effect on the yield stress of grooves inclined at 45 deg. to the axis of the test piece is discussed. In addition, tests are included to show the effect of notches in the test piece on the yield stress. (Paper No. APM-53-15, By C. W. MacGregor.)

Stresses in Curved Bars

BECAUSE of the difficulty of computing accurately the stresses in curved bars by the ordinary method, the author has derived simple formulas which give sufficiently reliable results with the use of a slide rule. The paper sets forth these derivations and gives several examples of the application of the formulas. (Paper No. APM-53-16, by H. C. Perkins.)

Strength of Thin Cylindrical Shells Under External Pressure

THE scope of existing formulas for the design of cylindrical tubes and vessels under external pressure, especially with regard to the determination of empirical constants and coefficients by systematic and comprehensive experimental data, is rather limited. The introduction and expansion of industrial processes, involving the treatment of materials under a vacuum or within double-walled chambers whose jackets are filled with steam under high pressure, has, in conjunction with reduction in operating costs by the use of large units, resulted in the building of cylindrical vessels of great size, in the design of which engineers have had to be guided largely by what little past experience they could muster. The dimensions and proportions of these units fall far beyond the scope of any previous experiments. With fabrication costs so high and with satis-

factory performance in service so important an item, the use of inadequate formulas can hardly be justified. Engineers called upon to execute these designs very rightly feel that they must have at their command workable scientific formulas, based upon logical application of accepted theories and capable of establishing proportions which will result in proper distribution and economy of material. It was because of the lack of adequate design formulas of this kind that the A.S.M.E. Special Research Committee on the Strength of Vessels Under External Pressure was organized. This paper represents the first attempt of the committee to meet the needs of designer and engineer. It is being published in advance of completion of research work on this project, to fill urgent needs in the profession and to bring forth suggestions, comment, and criticism from those interested in this work. (Paper No. APM-53-17a, by Harold E. Saunders and Dwight F. Windenburg.)

The Collapsing Strength of Steel Tubes

IN THIS paper the authors present a method for determining the collapsing strength of steel tubes on the basis of the physical and elastic properties of the metal in the tube, and the dimensions, out-of-roundness, and variation in thickness of the tube itself. This method applies to long, short, thick, or thin tubes. It was developed by considering the collapse of tubes in terms of compressive stress rather than external pressure, by reevaluating the work of other investigators, and from experimental results of the authors. Its application to the determination of the collapsing strength of commercial tubes is shown by illustrative examples. (Paper No. APM-53-17b, by T. McLean Jasper and John W. W. Sullivan.)

Spiral Springs

THIS paper presents a new theory relative to the stress, strain, and energy functions of spiral springs. This theory differs from the current one in that it takes into account the large deformations implied in the action of spiral springs. In the light of the theory, definite recommendations are made with reference to the design and mounting of spiral springs. It is suggested that springs may be loaded in such a manner as to eliminate all locally overstressed points as well as all friction between leaves. No grease or graphite, therefore, need be employed, and the efficiency of spiral springs may thus be increased: (1) By the utilization of space otherwise occupied by a lubricant, from 10 to 20 per cent; (2) by the elimination of all friction between leaves, from 20 to 40 per cent; and (3) by the elimination of locally overstressed points, from 40 to 100 per cent. (Paper No. APM-53-18, by J. A. Van Den Broek.)

MACHINE-SHOP PRACTICE

Transmission of Torque by Means of Press and Shrink Fits

THE most important formulas for calculating the stresses existing in press and shrink fits are presented, together with charts for readily obtaining numerical results when steel shafts and cast-iron or steel outer members are used. Equations and charts also are given for determining the pressure existing between fitted parts. From the records of a number of fits observed by the author and others, values of coefficients of friction are suggested for use with the pressure in computing the probable tonnage required in making a fit, and the torque capacity of a fit when no key is used. Equations are given for the tonnage and for the torque capacity. (Paper No. MSP-53-10, by J. W. Baugher, Jr.)

Haynes Stellite Cutting Tools

THIS paper describes briefly the physical properties of Haynes Stellite and gives the more important details of several types of machining operations on which it is being successfully used. Its most important property is red hardness. Measurements of hardness were made by an improved method up to 1100 C. The resulting data show that the cobalt-chromium-tungsten alloy is harder than high-speed steel at temperatures above 500 C. This is believed to account for its superior cutting quality.

When used for milling, three typical jobs on cast iron show 87, 100, and 27 per cent increased production, respectively, over that when using high-speed steel. On boring cylinder blocks the increase was 64 per cent. Turning operations in cast iron show 33, 35, and 60 per cent increase in production, and on steel, 123 and 93 per cent.

In general, Stellite bits and blades can be used economically on all operations on cast iron, semi-steel, malleable iron, bronze or similar metals, and on mild steel if the section is heavy and the tools are rigidly supported. It has not been successful on automatic or semi-automatic machines for cutting steel. (Paper No. MSP-53-11a, by W. A. Becker, E. E. Gordon, and W. A. Wissler.)

Tool-Steel Tools

METAL-CUTTING tools offered the trade today are vastly superior in quality to tools of a decade ago. The factors that govern the life of metal-cutting tools made from carbon, alloy, and high-speed tool steels, namely, design, steel, and treatment, are discussed in this paper, particular stress being laid on the importance of correct design. The important role played by cutting fluids or coolants as affecting the life of the tool, as well as the necessity of employing the proper grinding wheels and correctly using them, are also covered in some detail. (Paper No. MSP-53-11b, By A. H. d'Arcambal.)

A Survey of Surface Quality Standards and Tolerance Costs Based on 1929–1930 Precision-Grinding Practice

IN AN EARLIER paper presented at a meeting of the Chicago Section of the A.S.M.E. on March 18, 1929, the author reviewed the process of evolution through which the art of precision cylindrical grinding had passed up to that date. This paper reviews some of the defects which exist in the present-day accepted standards of finish of mechanical components, and represents an endeavor to maintain continuity by carrying the discussion through to the present-day standards of finish attainable by the abrasive process. It is pointed out that it is useless to specify extremely close limits of accuracy unless the measurements are made across basically plane surfaces.

Size control and its effect on cost of production, as well as the length of useful life, are discussed, and better finishes are advocated as a means of reducing the ill effects of high initial wear. A scheme for the establishment of definite standards of finish is put forward, and a finish-calibrating instrument is described. Emphasis is laid on the fact that there is no available short-cut method of obtaining ultra-fine-finished surfaces with a minimum of initial wear, and the author points out that standardization of finishes can be attained at low cost with little disruption of present methods; also that the subject of longer useful life to mechanical components is closely interlocked with the provision of a better standard of finish and the attendant benefits derived from close adherence to true limits of accuracy. (Paper No. MSP-53-12, by R. E. W. Harrison.)

Refinements in Finishing Cylindrical Bores

THE limitations of boring, reaming, burnishing, and broaching as finishing operations on cylindrical bores have led to the general use of abrasives for such work. Improvements in manufactured abrasives and study of operating data, together with improved methods of application, have made grinding a precision process. The cost of operation and the difficulty of bearing maintenance of planetary-type grinders have brought about the use of the expanding grinder or so-called "honing" method. The latter method has the advantage of speed, improved accuracy and finish, and low cost. It also makes possible the precision grinding of long tubes, gun-barrel rifling, and bores with ports, keyways, and relieved portions. (Paper No. MSP-53-12, by J. W. Hindes and James G. Young.)

The Uses of 16-Mm. Movies in Industry

INDUSTRIAL motion pictures may be readily divided into two distinct classes, namely, institutional and internal. Institutional pictures include productions employed for sales promotion and advertising purposes, or for any other use involving public exhibition. Such films should be made by the professional producer of motion pictures on standard-size 35-mm film. Internal uses include instructing employees in safety, in machine-shop practice, in plant housekeeping, and in fire prevention, as well as making records of construction and research findings, and of testing, assembling, sorting, and packing operations.

This paper deals only with the latter class, describing briefly some of the many internal uses of industrial motion pictures, and showing how members of the plant engineering staff can make such movies on amateur standard 16-mm film with inexpensive amateur equipment. (Paper No. MSP-53-14, By Maynard L. Sandell.)

Cemented Tungsten Carbide for Cutting Tools

IN THIS paper the author tells of the origin of cemented tungsten carbide and the most satisfactory method for making it. Because of its hardness its use for wear-resisting tools is valuable, and particular emphasis is placed on its use for cutting tools. The physical properties of cemented tungsten carbide and its economic value as a cutting medium are discussed. Design and care of the tools are essential factors in successful application. Proper support for the cemented-tungsten-carbide tip and allowance for proper clearance angles are essentials of design.

The tool set-up should be as rigid as possible, as chatter or vibration is detrimental to successful life. The critical speed at which the tool should run for a particular job should be determined, and the machine be operated below this. Grinding of the tool is important, and the author tells of proper grinding methods. Use of cemented tungsten carbide for cutting tools has resulted in increased machine speed, longer life per grind, reduced tool maintenance, less waste of material in setting up, and greater accuracy throughout a long run. (Paper No. MSP-53-15, by L. J. St. Clair.)

MANAGEMENT

Management by Exception

THE exception principle, as approved by the first leaders of industrial management, is expounded and advocated. It is described as a natural method of scientific management that directs when direction is sufficient and that compels when compulsion is called for, but that does not interfere with matters which are progressing in orderly compliance with a planned procedure, but which has positive methods of detecting and correcting variations from that procedure. Four rules of management by exception are stated. (Paper No. MAN-53-4, by Chester B. Lord.)

Training Apprentices and Foremen

THE experience of the author in labor problems and in legislation affecting workers provides a background for recommendations as to the proper training of apprentices and the development of foremen. Foremen generally are ignorant of the labor law, the health requirements, or of safety. The personnel manager and the safety engineer of the plant should work in closer contact with the foremen. Under the Smith-Hughes Act, the University of the State of New York has a course for training trade, industrial, and technical teachers. The courses are offered in large centers. Should labor management be taught in addition to these other subjects, there would be provided a good course for foreman teaching. (Paper No. MAN-53-5, by Frances Perkins.)

Value of the Safety Movement in the Industries

THIS paper outlines the various aspects of the industrial safety movement, its attractiveness, economies, and inherent possibilities. The safety movement has long since been divorced from altruistic conversation and put on a basis of cooperative helpfulness. Accordingly, the subject has been treated from a "cold" business standpoint in terms of dollars and cents; that is, in the approach to the problem the center of gravity has been shifted to the economic rather than humanitarian aspects. A brief historical review of the growth of the movement is first made, followed by some statistics of the losses in life and property caused by industrial accidents. The principal emphasis in what follows has been placed on the thesis, at present conclusively proved, that efficiency in production and safety are inseparably correlated. To afford a better perspective of the actual values involved, illustrative examples taken from the experience of different industrial companies are introduced. The role of engineers in accident prevention is next considered, and the discussion is concluded with several recommendations. (Paper No. MAN-53-6, by Jules Podnossoff.)

Symposium on the Stability of Employment in Industry

Manufacturing in Advance of Orders in Seasonal Industries. The methods used by American business concerns to reduce seasonal slumps have formed the basis of study for the opinions of the author, Edwin S. Smith. Efforts to reduce seasonality may take the form of striving for a more uniform sales demand throughout the year, an attempt to get orders further in advance of the season, or a more level production curve. The experience of a number of manufacturers is related in the effort to show preferred methods in many lines.

Unemployment—Causes, Palliatives, and Preventives. According to the author, Dr. Royal Meeker, the causes of unemployment are manifold, but come under the single head of maladjustment between production and consumption. The chief contributing causes are: Lack of planning of production to meet and not to exceed consumption requirements. Faulty distribution and utilization of the national income, causing alternating periods of over-saving and over-investment in production or intermediate goods, accompanied by under-spending and under-

consumption of immediate or final consumption goods, followed by over-spending and under-saving. Wide variations in the general price level, which mean changes in the purchasing power of money. Unforeseen calamities, including the marked overproduction of certain commodities, as well as the destruction of lives and goods by earthquakes, floods, storms, droughts, famines, etc. And finally, technological improvements due to new machines, methods, management, and organization.

Until recently little was known about the underlying causes of unemployment, and that little was known by very few. Hence the methods of treating this social-industrial disease, or accident, are for the most part merely palliatives, not cures or preventives. The palliatives which are most invoked to help us out of depression are: Soup and bread lines; odd jobs; "buy it now" slogan; wage maintenance; public works; regularization of individual plants; unemployment reserves in individual plants.

The only cure for unemployment is employment. There are, however, three major policies which may be inaugurated at once for the amelioration and prevention of unemployment: Planning a consumption-production program in all industries for several years in the future. Stabilizing the general price level, through credit and monetary control. Providing carefully planned, all-inclusive unemployment insurance. To make a start on any of the measures proposed requires a degree of knowledge, of cooperative spirit, and of authority which are at present largely lacking. But the evil of continually recurring unemployment, Dr. Meeker holds, demands bold and drastic action.

Employment Stabilization in the Procter & Gamble Company. The history of one company in stabilizing employment is detailed by the author, Harvey C. Knowles. Having but three presidents over a period of 93 years, a definite family policy has been carried out, resulting in a plan that virtually guarantees an employee that he shall have work for 48 weeks during the year; that he shall have a share in the profits; that in case of sickness he shall receive two-thirds of his pay for a year and a pension in case of disability; and that he may participate in a home-buying plan.

Discussion. The discussion of the preceding three papers constituting the employment-stability symposium is summarized by Charles W. Lytle in a report appended thereto. (Paper No. MAN-53-7.)

WOOD INDUSTRIES

Dust Explosions, With Special Reference to Woodworking Industries

EXPLOSIONS in flour mills have been common, but now the hazard is recognized in grain elevators, starch factories, sugar refineries, woodworking plants, textile mills, and other factories in which materials in the form of dust are manufactured. The woodworking industry is considered susceptible to this danger, especially since a great quantity of dust is created by saws, planers, and sanders, and recently in the manufacture of wood flour. More than thirty explosions in woodworking plants have been investigated. These indicate that wood dust is more easily ignited than some of the grain dusts. Precautionary measures are suggested, and regulations have been tentatively adopted for the prevention of dust explosions in wood-flour manufacturing establishments. (Paper No. WDI-53-9, by Hylton R. Brown.)

Study in Present-Day Wood Finishing

A SPECIFIC case of wood finishing is described in detail, type of plywood floor covering that is completely finished by the manufacturer, the operations being carried out while the flooring is continuously conveyed. The finish (a water-resisting coating applied to the under side of the flooring and a filter, two coats of lacquer, and a coat of wax applied to the face of the flooring) is completed in approximately two hours. (Paper No. WDI-53-10, by H. A. Derr.)

Utilization of Wood Waste in the Chemical Industries

THE principal uses, other than for fuel, for the wastes from the sawmill and woodworking industries are found in the following chemical industries: Destructive distillation, the manufacture of pulp, paper, and building boards, and those industries consuming large quantities of wood flour, principally linoleum, plastics, and explosives. The technical aspects of this waste utilization have been so satisfactorily worked out that a project of this sort may be evaluated almost entirely from the economic side. Competition from other raw materials, together with certain economic factors, requires that all of these operations be based on an ample, well-located, and relatively long-lived supply of waste wood. In many of these processes the waste wood must be separated either as to size or as to variety although in some cases similar varieties may be processed together. (Paper No. WDI-53-11, by Ben B. Fogler.)

Hydraulic Presses for Plywood

THE paper reviews the progress made in the clamping of plywood, especially in the last 35 years, when wooden hand screws and wooden-frame hand-screw presses were in general use. Improved hand clamps, improved hand-screw presses, and power-screw presses have their uses for certain classes of work and comparatively small output, and inverted-cylinder hydraulic presses are necessary for special methods and classes of work. Plywood is an artistic and utilitarian product with increasing appeal for both manufacturing and construction purposes. As the market for plywood products expands, new problems will necessitate further advances in press design. Plywood presses of the future may outdistance those of the present as much as the presses of the present demonstrate improvement over the old hand presses. (Paper No. WDI-53-12, by Harry G. Francis.)

Research in Wood Products

WOOD has widely different characteristics, and species may be chosen for a wide range of industrial and construction purposes possessing either high strength-weight ratios or qualities that permit cutting thin veneers, also possessing great ultimate strength or low specific gravity. It varies widely in color, grain structure, and beauty. Wood also has faults and limitations which can be largely corrected through intensive research. Wood expands when wet. Research with the X-ray has shown the reason, and has pointed to a way of rendering wood nearly non-expansive. Wood can be made fire-resistant, but tests must be conducted under both heat and strain conditions to be of practical value. Preventive measures can be taken to lengthen the life of wood by toxic-chemical treatments to eliminate decay. Wood-finishing methods can be greatly improved by scientific adaption of the right principles. (Paper No. WDI-53-13, by James W. Lawrie)

ENGINEERING STANDARDIZATION

Form and Arrangement of Published Standards

COMPLETION of a series of recommended practices for form and arrangement of published standards has recently been announced by the American Standards Association. These recommendations have been developed by a special committee appointed several years ago. They are intended for the assistance of the Association's member-bodies which are sponsors for its numerous projects and desire to publish the results in a uniform way. F. L. Rhodes, outside plant and development engineer of the American Telephone and Telegraph Co., is chairman of this committee, and E. M. Matthews is secretary. The committee's report passed successively through numerous drafts and was finally presented to the A.S.A. at its annual meeting, December 9, 1931. It is expected that at a later meeting the report will be discussed in detail and acted upon.

Under the present arrangement for publishing standards approved by the A.S.A., a large number of organizations have a part. These groups are also carrying on standardizing and publication activities within their own organizations. Consequently, in the process of working out their problems of form and arrangement with different printers, the publications of the various groups naturally show considerable differences. Accordingly, there were divergent opinions on how far the committee should go in making a selection from the details of these differences. Controversial questions could have been avoided by the committee, obviously, if the scope of requirements had been made sufficiently general and inclusive.

Furthermore, if the practices were solely for use by groups that have already gathered experience in publishing standards and similar printed matter, there would be less justification for going into details. But from the broader standpoint of the needs of all groups engaged in the preparation and publication of standards, the committee decided that a real service would be rendered those not so well acquainted with the problems by including practical information in considerable detail and a helpful discussion of the background of the work.

One problem encountered in setting up these practices for form and arrangement was that of page size for standards publications. The determination of the proper size of page was not included in the scope of the work assigned to the committee, and although the advantage of using only one size has been appreciated, it did not seem desirable at the present time to recommend the exclusive use of one size of page. At the beginning of the work, the committee selected the $7^3/_4 \times 10^5/_8$-in. page as a tentative size for convenience in preparing recommended practices involving surface dimensions and spacings. A statement recognizing three other sizes of pages as suitable for published standards will be found in the report. These sizes are 6×9, $7^3/_4 \times 10^5/_8$, $8 \times 10^1/_2$, and $8^1/_2 \times 11$ in., and the half-size $5^1/_4 \times 7^3/_4$ in.

The differences in form and in printing practices used by some groups previously referred to resulted in the inclusion of alternative procedures in the description of a number of practices. Examples of these will be found in the pamphlet in the sections dealing with type, section headings, indenting notes in the text, etc.

The committee is of the opinion that when its recommendations are considered as a whole the relatively few cases where more than one way of doing the work is recognized will serve to provide for a certain flexibility which may be needed in beginning the application of such recommended practices. It is hoped, however, that experience in using the new practices will eventually permit the elimination or the reduction of these duplications.

It is not intended at present that these recommended practices supersede the suggestions for the preparation of safety codes contained in PR30, "The Preparation of National Safety Codes," published by the American Standards Association. Neither do these practices apply to the publication of bound-book standards or reprints therefrom. Copies of this report may be had from C. B. LePage, Assistant Secretary, A.S.M.E., who is a member of this special A.S.A. Committee.

NEW AMERICAN STANDARDS

The following standards were approved by the A.S.A. during the month of December 15, 1931, to January 15, 1932.

Cast-Iron Pipe Flanges and Flanged Fittings for Maximum Non-Shock Working Hydraulic Pressure of 800 Lb per Sq In. (Gage) at Ordinary Air Temperatures. (B16b1)

(American Standard.)

Sponsored by the Heating and Piping Contractors National Association, Manufacturers Standardization Society of the Valve and Fittings Industry and The American Society of Mechanical Engineers. Published by The American Society of Mechanical Engineers.

Code for Testing Domestic Refrigerators Using Ice (B38c1)

(American Recommended Practice.)

Sponsored by the American Society of Refrigerating Engineers and the U. S. Department of Agriculture, Bureau of Home Economics. Published by the American Standards Association.

Electric Railway Control Apparatus (C48)

(American Standard.)

Sponsored by the American Institute of Electrical Engineers.

Symbols for Mechanics, Structural Engineering and Testing Materials (Z10a)

(American Standard.)

Sponsored by American Association for the Advancement of Science, American Institute of Electrical Engineers, American Society of Civil Engineers, The American Society of Mechanical Engineers and the Society for the Promotion of Engineering Education. Published by The American Society of Mechanical Engineers.

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretations of the Committee in Cases Nos. 675 (Reopened), 693, 699, and 700 to 704, as formulated at the meeting on December 4, 1931, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE NO. 675 (REOPENED)

Inquiry: Does the reply to section *a* of Case No. 661 permit the use of fusion welding of plain and wholly unstayed boiler furnaces under the conditions set forth?

Reply: The reply is intended to refer to the particular furnace under consideration and does not apply to plain and wholly unstayed boiler furnaces. If the welds are stress relieved and bend tests are made of the welds as specified in the welding rules, it would be sufficient for the particular joint in question which is under compression. A revision to cover welds under compression is contemplated.

CASE NO. 693

Inquiry: When the carbon-arc process of welding is used, is it necessary, in making double-welded butt joints without V'ing or scarfing the plates, to chip, grind, or melt out the metal at the base of the weld from the second side of the plate to be welded, as is required by Par. U-72 revised?

Reply: The requirements in Par. U-72 revised, for chipping, grinding, or melting out metal on the reverse side of a double-welded butt joint, are intended to eliminate impurities and obtain a clean surface for the second side welded, and are not intended to apply to any process of welding by which proper fusion and penetration are otherwise obtained and no impurities remain at the base of the weld. The same qualification test specimens and test requirements must be made as for the other methods of welding.

CASE NO. 699

Inquiry: What is the maximum length of a pipe connection for a steam gage before it shall be classed as a "long pipe" mentioned in the last section of Par. P-296?

Reply: It is the opinion of the Committee that a length of pipe longer than 10 ft should be classed as "long" within the intent of Par. P-296.

CASE NO. 700

(In the hands of the Committee)

CASE NO. 701

Inquiry: An interpretation is requested of the requirements for test plates for longitudinal joints in Par. U-68 of the Code as follows:

a Can these test pieces be cut from any portion of the plate as rolled?

b Can these test pieces be cut longitudinally or transversely to the rolling direction of the plate as best suits the mill's convenience?

c When two or more plates are ordered of the same thickness, can the tests for all of the plates be cut from one plate as rolled?

d Should fabricators specify the size of test pieces required on the assumption that different shops might not have the same methods for cutting the test pieces into various sections required?

Reply: a, b, and *c.* It is the opinion of the Committee that the plates for test samples may, under the requirements of Par. U-68, be taken from any part of one or more plates that conform to the specifications for the material that is used in the fabrication of the welded vessels, and without reference to the direction of the mill rolling.

d The sizes of test specimens as given in the Code will determine the size of the test plates from which the test specimens are to be cut, which sizes would presumably be given by the purchaser.

CASE NO. 702

Inquiry: Under the new rules for fusion welding, what is the tolerance for the corner radius of the specimen for free bend tests? This corner radius is specified as $^1/_{10}t$.

Reply: It is the opinion of the Committee that the corners should be rounded to a radius not to exceed $^1/_{10}t$. This measurement was intended as a maximum and not a mandatory fixed amount.

CASE NO. 703

Inquiry: Is it necessary, in the construction of an ammonia condenser in which non-ferrous tubes are used, to follow the requirements for tubes in Table P-5 of the Power Boiler Code? The tubing can readily be made to meet the requirements of this table, but the question is raised as to why the Power Boiler Rules should apply to constructions covered by the Code for Unfired Pressure Vessels?

Reply: Where there are no rules in the Code for Unfired Pressure Vessels to cover a particular part of a construction, the Committee would recommend that if there are rules in the Power Boiler Code which cover this part, they should apply. It is further the opinion of the Committee that such a vessel in which all of the parts meet the requirements of the Code for Unfired Pressure Vessels supplemented by the Power Boiler Code can be stamped with the Code symbol for unfired pressure vessels. A revision of the Code to this effect is under consideration.

CASE NO. 704

(In the hands of the Committee)

Correspondence

CONTRIBUTIONS to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed at all times are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

Action of Slags on Firebrick

TO THE EDITOR:

The papers by Messrs. Klinefelter, Rexford, and Hursh[1] are very important contributions, through two markedly different angles of approach, to a problem which to date has resisted easy solution, namely, that of devising satisfactory test methods for forecasting in the laboratory the action of slags on firebrick. While this serious problem has by no means been completely solved, nevertheless the data presented are very promising, and seem to indicate that the methods now being developed by the authors will eventually prove practical.

The consistency of the results reported by Messrs. Klinefelter and Rexford, in comparison with actual service in boiler furnaces, is extremely interesting, and immediately indicates the merit of the U. S. Bureau of Standards method. A feature of extreme importance is the fact that the critical-temperature range, above which slag attack is severe, can be evaluated within reasonable limits; previously this has not been possible. However, it should be kept in mind that the quenching method for studying slagging action requires highly trained technicians of specialized experience, in order that it may be successfully used and interpreted. This fact by no means reduces the value of the test, but probably limits the extent of its application. The chances are that the method can be successfully handled only by a relatively small number of well-equipped research agencies; its use as a plant or control method seems to be improbable.

The University of Illinois method seems to be capable of more general application. It appears to possess definite possibilities as a laboratory test method, with certain features not obtainable with other slag-test methods now in use. However, before endeavoring to reach comprehensive conclusions based on data secured by this test, it would seem desirable to determine first how the order of excellence of various brands, when tested by this method, compares with service results; how closely the results on any one brand with the same slag may be duplicated in tests run at various times; the limits of accuracy of the test; and what deviations between test samples may be considered significant. For example, in Table 4 of Professor Hursh's paper, there was a greater variation in the depth of erosion of brand "St. 2" in several tests than between different brands in the same test, from which generalizations have been made. Certain conclusions reached regarding reducing conditions in the furnace, burn, high-alumina brick, etc., seem to be somewhat contrary to frequent experience based on service records. It would appear that in these instances the differences in slag erosion of the brands tested may have been smaller than the significant deviations. As a larger fund of data is obtained through additional tests, the value of the test method will be more fully demonstrated.

E. M. SARRAF.[2]

Pittsburgh, Pa.

[1] "Comparative Resistances of Refractories to Coal-Ash Slags," by R. K. Hursh, and "Action of Slags on Firebrick and Boiler-Furnace Settings," by T. A. Klinefelter and E. P. Rexford; respectively papers FSP-53-21 and FSP-53-22, Trans. A.S.M.E., vol. 53, no. 14, September–December, 1931.

Invention, Unemployment, and Patent Control

TO THE EDITOR:

If a mechanical device comes into use and replaces with its energy the toil of a thousand men, it accomplishes something. But if the device is owned by the factory owner, who alone profits through its use, and the thousand of men relieved of their toil find they are without means of support, then also it accomplishes something. In effect, it takes the profits of toil from one thousand pockets and places them into one. It creates another millionaire and a thousand unemployed, not to mention their dependents.

If mechanical devices can relieve toil and hardship, then they should be so controlled as to afford pleasure and recreation to the greatest number possible. If some such consideration is not given to the problem, then the machine age will of necessity become a failure. Surely a man is happier with toil and food than without both.

A great step forward in connection with this idea would be Federal control of patents. Let us assume that a man invents a device that will eliminate man power. Surely he is entitled to remuneration for his genius, but after that, what? Would he rejoice in seeing hundreds of men rendered unable to support themselves or their families, and glory in the marvelous success of the company that purchased the patent? He should not, even if he would, and the company, instead of being able to purchase such a patent, should be permitted only to secure a license for its use from the Federal authorities, for which it would pay a reasonable royalty. Such fees, if collected from innumerable patents, would assist in paying governmental expenses and in that way lighten the burden of taxes on the people as a whole.

Such a plan would be no deterrent to mechanical genius. Today a man far ahead of the times with his ideas finds his patents expiring when they are, so to speak, just coming to life. The life of a patent should be extended to at least fifty years, and the inventor guaranteed for a certain period a fair percentage of the income from permits for its use granted by Federal authority. And in no case should a patent be used without payment to the inventor thereof, whether or not the patent had expired. After fifty years the patents should become the property of the Government.

If mechanical engineers hope to lighten the burden of toil with labor-saving devices, they must adopt a plan that will not create more fortunes and at the same time render thousands homeless and bring about starvation, want, and unhappiness.

BERTELL W. KING.[3]

New York, N. Y.

[Two questions seem to be involved in Mr. King's communication: (1) the general relationship between patent control and unemployment, and (2), assuming there is seen a relationship, the best means of controlling the use of inventions. Comment is invited.—EDITOR.]

[2] Chemical Engineer, Harbison-Walker Refractories Company.

[3] 17 Battery Place.

AMBROSE SWASEY HONORED

Testimonial Luncheon Tendered to Past-President of A.S.M.E. in Cleveland on the Occasion of His Eighty-Fifth Birthday

AMBROSE SWASEY, Honorary Member and Past-President of The American Society of Mechanical Engineers, and surviving founder of the Warner & Swasey Company, Cleveland, celebrated his eighty-fifth birthday on Saturday, December 19, 1931. This was made the occasion of a testimonial luncheon at the Cleveland Chamber of Commerce, tendered to Mr. Swasey by the officers of the Chamber.

This luncheon, which was attended by about ninety men—including leading citizens of Cleveland, noted educators, and representatives of national engineering societies and of American industry—was made the occasion not only of fine tributes to the venerable engineer and patron of the arts and sciences, but also of the unveiling of a portrait in oils (see page 99), done by Philip A. de Laszlo, of London. In March it will be hung in the rooms of the Cleveland Chamber of Commerce.

Presiding at the luncheon was Randolph Eide, official head of the Ohio Bell Telephone Company and also of the Cleveland Chamber. After an invocation by Dr. Harold C. Phillips, pastor of Mr. Swasey's church in Cleveland, Mr. Eide introduced Mr. de Laszlo, who proposed a toast to the guest of honor. At this point the assembled guests arose and the artist drew the cord which unveiled the portrait.

Following Mr. de Laszlo, Dr. Calvin W. Rice, Secretary, A.S.M.E., Dr. William Gerry Morgan, of Washington, who is a neighbor and the personal physician of Mr. Swasey's during the summer months at Exeter, New Hampshire, and Hon. James R. Garfield, son of the twentieth President of the United States, Secretary of the Interior in the Roosevelt Cabinet, and a noted lawyer, spoke appreciatively of Mr. Swasey's life and work.

A large number of congratulatory letters, which will be bound and presented to Mr. Swasey, were shown. Those from the following were read by Mr. Eide: Herbert Hoover, President of the United States; Sir Robert A. Hadfield, British steel magnate; Charles Eugene Schneider, head of the famous Creusot Works in France and John Fritz Medalist; Dr. J. S. Plaskett, Director of the Dominion Astrophysical Laboratory in British Columbia; John R. Mott; Dr. Henry S. Pritchett, Dr. W. W. Campbell, of Lick Observatory; Dr. Michael I. Pupin, noted physicist; Dr. George E. Hale, honorary director of Mount Wilson Observatory, and Charles M. Schwab.

After the reading of these letters, Mr. Swasey arose. It was obvious that he was deeply moved.

"Friends from far and near," he said, "I wish that it were possible for me to express my feelings. All this touches my heart, but I am quite unworthy of all that has been said here."

At the end of his response, Mr. Swasey recited from memory his favorite poem. The formal part of the meeting then came to an end, and Mr. Swasey held an entirely informal reception for those present as he walked among them.

HIGH POINTS IN MR. SWASEY'S LIFE AND WORK

It is fitting to recall at this time some points in the life and work of Mr. Swasey. Born in Exeter on December 19, 1846, he grew up on a farm at the edge of the village and was educated in the Exeter public schools. Showing marked mechanical tastes from an early age, he began his actual mechanical career in a small machine shop in Exeter, where in the spring of 1866 he first met his lifelong associate, the late Worcester Reed Warner, whose sudden death at Eisenach, Germany, on June 25, 1929, terminated one of the most remarkable and fruitful engineering partnerships in all industrial history.

In the spring of 1869 Ambrose Swasey and Worcester Warner went together to Hartford, Conn., and entered the employ of the Pratt & Whitney Company, a manufacturing organization then only nine years old. In the development of that organization Warner and Swasey played no small part during the following eleven years, Mr. Swasey being eventually in charge of one of the most important of the machine-tool-building departments.

In 1880 Messrs. Swasey and Warner decided to leave the Pratt & Whitney Company in order to establish in the rapidly growing Middle West a machine-tool-building industry of their own. Their initial experiment was in Chicago, but almost immediately they discovered that they had gone too far west to obtain the necessary skilled workmen, so they "backed up" to Cleveland, where their venture was successful from the very start.

From small beginnings made almost entirely with their own money, a plant developed on what is now Carnegie Avenue, near 55th Street, which for more than fifty years has been notable in the field of turret lathes, and in the apparently unrelated field of fine optical instruments—including many of the world's greatest astronomical telescopes.

Both of these engineers took an active interest in civic affairs, in church work, in the upbuilding of museums, universities, and other educational institutions, and in technical societies, both local and national. Both were among the Founders of The American Society of Mechanical Engineers in 1880, both served as Presidents of the Society—Mr. Swasey's term having been in 1904—and both were made Honorary Members—this distinction having been conferred upon Mr. Swasey in 1916. In 1914 Mr. Swasey established the Engineering Foundation, which he has endowed with large sums of money to insure altruistic engineering research, with functions comparable to similar foundations for research in medicine and surgery.

Mr. Swasey, who is a trustee of Denison University, Granville, Ohio, and of Adelbert College of Western Reserve University, Cleveland, has been awarded honorary degrees of Doctor of Engineering by Case School of Applied Science, 1905, Doctor of Science by Denison University, 1910, and by the University of Pennsylvania, 1924; and Doctor of Laws by the University of California, 1924, and the University of Rochester, 1925. He is a member of numerous engineering and scientific societies other than The American Society of Mechanical Engineers, both in America and in Europe.

Ambrose Swasey not only demonstrates what it means to grow old gracefully, in the meantime adding good works to a lifetime of good work, but beyond all this he demonstrates—and for years has demonstrated—that a great engineer can at the same time be a great citizen in all that the broad sense of that term implies. The keynote of the Cleveland luncheon was honor to Ambrose Swasey, great American citizen.—GUY HUBBARD.

NOW WE KNOW EARNINGS— WHAT NEXT?

A.S.M.E. Committee on the Economic Status of Engineers Plans Action

THE task given the Committee on the Economic Status of Mechanical Engineers, on its appointment in May, 1928, was to determine the engineer's economic status and to make suggestions for its improvement. The Committee soon saw that the problem was more inclusive than earnings alone, and that it also involved the professional and social status of the engineer.

The first job of the Committee was a study of earnings. This job has been done. Through the cooperation of over 9000 members and of the Local Sections, exceptionally accurate information as to the earnings and professional status of mechanical engineers has been obtained. From the start, however, the Committee was determined that this investigation should lead to positive action and not be "just another questionnaire." At the Annual Meeting it announced the following plans to put this information to work.

The most valuable use that can be made of this material is, of course, by the individual engineer. To make it available to him in such a way that he can reach his own conclusions, articles consisting primarily of charts were published in the September, November, and December issues of MECHANICAL ENGINEERING. By turning to the appropriate chart, any engineer who is interested can readily discover what are the normal earning levels at all ages, in his locality, in his industry, in his type of work, or for a man of his type of education; and so can make his decisions on the basis of facts. To a considerable extent he can also determine the aspects of his work which it is most important for him to emphasize in order to develop himself professionally.

In order to bring this material together in a single unit for distribution, the Committee is now publishing the three articles in a single report.[1] It has also prepared complete sets of slides for use by the Local Sections in bringing these findings before their members for frank discussion of their significance.

Besides putting this material in the hands of members, the Committee plans to see that it reaches those people responsible for action. The report is being sent to deans of engineering schools and to engineering, management, and similar associations. In addition, wherever the report indicates a condition calling for remedial action, the specific situation is being brought to the attention of those concerned. Thus, the report is being sent to influential organizations in those localities and in those industries where engineering salaries fall seriously below the general standards of the profession. With it a letter is being sent which points out the particular condition and seeks to make clear that, apart from some modifying circumstance, if these localities and these industries desire to secure the best engineering talent, they must pay the "going rate" of the profession. Similar action will be taken to see that persons in influential positions in leading companies realize the extent to which branches of engineering, such as research and design, which are underpaid in proportion to general professional standards, must be paid a higher rate if the best engineering brains are to be attracted into this vital creative work.

Perhaps the greatest significance of the study is the indication it gives that, regardless of his speciality, the mechanical engineer can rarely rise to his full stature in his profession unless he is a "man of full habit." Whether he be an executive, or a creative designer, his chances of attaining the higher positions in his profession are small unless he is both a man of technical talent and a man whose fullness of mind and heart give him a capacity for leadership among his fellows. The Committee believes that the Society has an important responsibility for bringing about the realization by the profession of this well-rounded conception of the engineer, and of attracting into the profession young men qualified to attain it.

The Committee plans to start at the bottom in seeking to do this. They plan to help boys who are considering becoming mechanical engineers to decide whether or not to enter the profession. To this end the Committee is preparing an article for distribution in preparatory and high schools, which will outline the general scope and activities of mechanical engineers and emphasize the type of preparation and the qualities that contribute to professional success. Because of the information secured through the survey, the Committee is able to give definite facts rather than vague opinions. It is, for example, able to say with conviction that:

1. A good professional education distinctly pays
2. Success is largely won in the first fifteen or twenty years of professional work. It depends upon the extent to which technical skill is combined with hard work, clear thinking, and capacity to learn from experience in developing the "graduate" into a professional man of large stature
3. An engineering training offers little to men of mediocre abilities, but provides a great opportunity for men of outstanding qualifications
4. A substantial majority of all but the youngest mechanical engineers occupy executive positions, either as heads of technical work or as general executives. Engineering is thus a pathway to executive opportunity
5. Even in its more technical branches, mechanical engineering calls for men who are professional in their capacity to deal with the human as well as with the material factors of industry.

Similar information will be provided for colleges. For young engineers at work the Committee plans to work with the Local Sections. Not only will it provide the Sections with data, but it will work with them in seeking to broaden and enrich the experience of the young engineer. It will seek to assist the Sections to stimulate post-college training and activities, such as discussion groups. It will seek to assist them to bring into the local meetings a broader point of view

[1] There is also a considerable amount of unpublished data at the headquarters of the Society which the Committee will be glad to make available to any one who is interested.

and a relation to the civic and cultural life of the community.

A final step is to bring about the certification of engineers on a basis of combined technical, creative, and executive qualifications. In this work especially, but also in carrying out most of its other plans, the Committee proposes to work as far as possible with the other engineering societies. Clearly, this is a matter for the entire profession. Fortunately, other societies are appointing committees, and we are sure of wholehearted cooperation from them. Our Committee, in conference with committees from the other engineering societies, has already recommended to the Council a definite program of joint action.

Throughout, the Committee realizes the value of the highly trained creative engineer upon whom society depends for the technical advances which are fundamental to civilization. The Committee does not want to make an executive out of him. It does want, however, to bring more executives into the profession, and at the same time to support the splendid work of the creative technician by assisting him to develop that full life which marks the professional man.

It is with this purpose and through these means that the Committee is seeking to make its survey more than a matter of passing interest—a source of positive development in the Society and the profession. In all its work the Committee is placed in a much stronger position due to its investigation. In its contact with members and sections, in its work with schoolboys, professional students, and young professional men, the investigation has enabled it to act largely on the basis of objective information and not on unsupported intuition. The Committee realizes, however, that whatever results are obtained depend primarily on what the individual engineer and the Local Sections do. It solicits their active interest and help in constituting the survey, in which they cooperated so generously, a positive step forward for the mechanical engineer.

BOOK REVIEWS AND LIBRARY NOTES

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the United Engineering Trustees, Inc., as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Business Administration

HANDBOOK OF BUSINESS ADMINISTRATION. W. J. Donald, Editor in Chief. Sponsored by American Management Association. McGraw-Hill Book Co., Inc., New York, 1931. Flexible binding, 4½ × 7 in., 1753 pp., diagrams and tables. $7.

REVIEWED BY WALTER RAUTENSTRAUCH[1]

THE wide scope of executive authority frequently reposing in one individual, together with the need of coordinating the operations of a single executive function with other departments of operation, creates a demand for information on problems of management, which this book is prepared to meet.

Managers who have responsibilities which extend beyond the scope of intimate experience will find this book a real help. As stated in the preface, "This 'Handbook of Business Administration' will, to a considerable extent, meet this educational need by providing in a form convenient for study, the fundamentals and the procedures of managerial policy and technique which may be put to use by business executives as problems arise and as the business process changes."

The list of contributors contains the names of 128 persons, each of whom is qualified by experience to deal authoritatively with the subject assigned.

The book is divided into six sections:

Marketing (11 chapters, 326 pages)
Financial Management (9 chapters, 205 pages)
Production Management (13 chapters, 212 pages)
Office Management (9 chapters, 286 pages)
Personnel Management (13 chapters, 436 pages), and
General Management (8 chapters, 264 pages).

A handbook is considered generally like a dictionary—a source of information but not very interesting reading. This book is of a different type with respect to the latter attribute. It *is* interesting reading.

The book is also well edited. Each chapter begins with a clear statement of the scope of the subject-matter dealt with, and an outline of the principal divisions of treatment. The matter presented is drawn from a wide range of industries to illustrate the principles discussed. A wholesome feature of the book is the absence of so-called systems. The emphasis in each chapter is on the principles involved rather than on the "rules of management." The book is therefore well adapted for use in industrial-engineering courses and in management courses in schools of business, as collateral reading matter.

The first chapter in the section on marketing presents suggestive material on market analysis. The second chapter, on advertising, discloses methods for determining the kind of advertising suited to particular products and ways of measuring the results of advertising effort. Chapter 3 is on "the selection of merchandise which will meet the needs, wants and desires of consumers." Price making and price policy are discussed in Chapter 4. Chapter 5, on the choice of marketing channels, is especially well written, as is also the sixth chapter,

[1] Professor of Industrial Engineering, Columbia University, New York, N. Y. Mem. A.S.M.E.

on setting the sales quota. Chapter 7, on the sales force, is the work of ten contributors. The essential problems which a sales force presents are discussed in this chapter.

The relation between national advertising on one side and field selling on the other is discussed in Chapter 8. The material in Chapter 9, on the determination and control of marketing costs, could have been presented with more effect if it had been distributed throughout the preceding chapters, as a part of each topic dealt with in those chapters.

The problems of retailing by department stores and chain stores are briefly considered in Chapter 10, and export management even more briefly in the following chapter.

There is very little repetition in these eleven chapters on marketing. Both the manufacturer and merchant may read this section with profit. It will be particularly helpful if they will compare their own programs of marketing with the principles and policies discussed in this book.

The section on financial management begins with a short plea for a recognition of the importance of the financial executive in large organizations. The second chapter presents the balance-sheet ratios suggested by Wall and Duning, and a procedure for budgeting the financial requirements of a business, particularly in those industries affected by serious price fluctuations. This chapter is descriptive of the practices of an oil company. It would have been more useful to the average business man if a procedure in the creation of a master budget and departmental budgets had been presented.

The problems of incorporating a business, the rights and duties of stockholders, the functions of boards of directors, the finance committee, and various financial officers, and methods of short-term borrowing are described in an interesting manner in Chapters 3–6.

Chapter 7, on consolidations and mergers, should have been omitted. Any business man contemplating a problem of this nature should not rely on such meager information. The average business man will have little occasion to refer to it. On the other hand, Chapter 8, on depreciation and obsolescence, should have been enlarged to include descriptions of representative practices in accounting for depreciation.

This section on financial management closes with a chapter on insurance which is well worth reading. If every business man would read the chapters in this section and incorporate the principles and spirit of its contents in his business, there would be far fewer failures in the future.

The third section of the book treats of production management, and begins with a short chapter on the fundamentals of production. The writer of this chapter fails to state the basic characteristics of the modern factory systems. The great urges from which grew our present methods of manufacture—to shorten the quantity-time factor of investment necessary to create a unit of product and to accomplish the quickest turnover of working capital—are not mentioned.

The second chapter, on organization of the manufacturing division, fails to outline the essential divisions of effort of the manufacturing function, nor does it set forth the basic principles of its organization. It consists of a series of weak general statements. Chapters 3 and 4 present a short analysis of the problems of planning, designing, and constructing industrial plants, and their layout with reference to the movement of materials and to the service departments. Some of the problems of selecting machinery and equipment are well stated in Chapter 5. In this chapter, however, as well as in some others throughout the entire book, occur such weak statements as, "Here again a careful balance should be struck, taking into consideration all factors." This occurs under the heading "Dies, Jigs, and Patterns." This statement can be of no possible help to any one. What are the factors, and how may they be taken into account? The best modern teaching recognizes that nothing is accomplished by telling Johnny to be good, Johnny needs more specific guidance. If space limitations prohibit an analysis of the problems of determining the jig and fixture requirements of a manufacturing business, the reader might at least be referred to the excellent paper by Professor Roe on this subject.

Research development and design, from the standpoint of its organization and functioning in a business, is set forth in a sensible manner in Chapter 6.

In Chapter 7 the principles of production control are presented, and references to further reading are listed. This is a well-written chapter, dealing with all types of manufacture, and should be studied by every plant executive. Chapter 8 discloses the principles and techniques of motion study in a very interesting manner. Wage-payment plans for direct labor and for other employees are discussed in Chapter 9. A short discussion on quality and inspection suggests that most things done in a plant should be inspected. The next chapter (11), on operating data for line officials, illustrates the use of standard cost data in reports to executives. This chapter is very "sketchy." Chapter 12, on purchasing, states the bases on which the purchasing function should be organized. It is written in a convincing, forceful manner. The final chapter of this section deals acceptably with the problems of storekeeping.

One leaves this section of the book with a feeling that the full possibilities of the subject have not been realized. A better-coordinated treatment, with emphasis on basic principles and apt illustrations of their embodiment in certain practices, would greatly strengthen the treatment of this important subject.

The section on office management is very complete and is practical. It begins quite properly with a statement of the problems an office manager must solve. The chapter on the physical factors, in which the selection and management of office equipment are discussed, is one of the best ones in the book from the standpoint of definitive information and clarity of style. The next chapter, on office personnel, is very good. Methods for selecting and training clerical workers are described at length.

The preparation and use of manuals dealing with time off, special privileges, additional compensation, and many other problems are discussed, and the policies of representative concerns are reported. The problem of fixing salaries and granting promotions is presented in the fourth chapter.

Chapter 5, on the measurement of office output, is written exceptionally well. The policies and practices of filing, mailing, and other services are often hard to decide upon, and therefore the sixth chapter, on office services, will be read with interest by many executives. This is also true of the next chapter, in which the design and use of forms are discussed.

Office planning and control are treated in a thorough manner in Chapter 8. The final chapter of the section considers the supervisory relationship of the home office to the branch office, and the discussions are based upon the results of a questionnaire answered by about fifty representative concerns.

This entire section will be read with interest by managers, for it is not only clearly written but also gives much information on the practices of other companies. Most executives desire to base their policies on proved experiences, and therefore any handbook to be used with confidence must report the policies and practices of representative groups.

The largest section of the book is devoted to personnel management. The first chapter presents the duties and pro-

cedures of a personnel department. The second chapter, on budgeting personnel requirements, should have been included in a general chapter on budgeting. The third chapter, on maintenance of the working force, is very clear and specific on the problems of selecting, placing, and introducing employees. A brief article on labor turnover also appears in this chapter.

Job analysis for position classification is dealt with in Chapter 4, but the average reader will not get much out of it. A very sensible statement of the problems of wage incentives introduces the next chapter. The chapter on supervision contains some good ideas, as does also the next chapter, on training and education. In this latter chapter it is interesting to note the emphasis placed on management as a "training job." Every good executive is a good teacher. Meeting the hazards of the worker in matters of health, disability, and old age and associated problems is presented fully by thirteen well-qualified writers. This important aspect of the industrial problem is receiving the sympathetic attention of an increasing number of executives, to whom these pages will be of material assistance.

Financial plans for employees, dealing with the problems of stock ownership and thrift plans for employees, together with the problems of social, recreational, and athletic activities, are the subjects of the two following chapters. These will be read with much interest.

The next three chapters, on collective bargaining with unions, employee representation, and labor laws in the United States, bring the essential factors of these problems to a sharp focus. Every manager of labor should be informed fully on the contents of these pages.

This whole section is written so well that it alone justifies the publication of the book.

The final section of the book is devoted to general management. The problems of public relations, the use of research and specialists, and many other topics of interest to business executives are presented by well-qualified writers.

The mechanical features of the book are good: it is well printed and bound; it lies open on the desk; the index is extensive.

It is hoped that future editions will include a more extensive bibliography. Some consideration of the methods of determining the economic characteristics of business enterprises would also be helpful.

Credit for this excellent publication is due not only to the editor in chief, but also to Leona Powell, managing editor, and the associate editors, Kenneth B. Anderson, Edith King Donald, and Mary Rodgers Lindsay.

The Quest for Power

THE QUEST FOR POWER FROM PREHISTORIC TIMES TO THE PRESENT DAY. By Hugh P. Vowles and Margaret W. Vowles. Chapman & Hall, Ltd., London, 1931. Cloth, 5½ × 8½ in., 354 pp., illus.. 15 s. net.

REVIEWED BY GEO. A. ORROK[2]

HUGH AND MARGARET VOWLES have attempted in this volume to record the story of what they term "man's greatest adventure." They have divided the subject into three parts, the first of which they call the "Apprenticeship of Toil," where the story of man, the tool maker, is told with the development of craftsmanship, early structural and transport achievements, a transition from the stone to the bronze and then to the iron age; with chapters on mining, measuring, and time reckoning, and on engineering in Graeco-Roman antiquity.

[2] Consulting Engineer, New York, N. Y. Mem. A.S.M.E.

The second part, the "Age of Power," tells the story of the coming of the age of steam, made manifest by the genius of James Watt, and traces the development of the boiler, engine, steam turbine, electric generation and transmission, and internal-combustion engines, as well as water-power plants, with a short review of the development of machine tools.

The third part deals with the materials of power: coal, oil, and alcohol; iron and steel; copper, aluminum, and the other non-ferrous metals and alloys. These three sections are followed by an epilogue on the World Power Conferences which have been held in the last eight years, and a short chapter on the possibilities of the future. The book is profusely illustrated, and particular care has been exercised in the choosing of the illustrations and portraits.

The whole book is well written, logically put together, and besides being attractive to the general reader, both young and old, will be of considerable value as a work of reference.

The final chapter, on the possibilities of the future, will be of interest to the engineer as it discusses such subjects as the gas turbine, wireless transmission of power, tidal power, schemes for utilizing the internal heat of the earth, the utilizing of the difference in temperature between the heated water on the surface of the ocean and the cold water in its depths, and between the temperature of winter air in the polar regions and that of the water under the ice sheets. The authors refer to a report on the desert surveys of Egypt, where a scheme is proposed for allowing some 40,000,000 tons of sea water per day to flow into a depression 400 feet below the sea level, generating thereby about 160,000 horsepower. The comments on windmills and other subjects are interesting.

The Physics of High Pressure

THE PHYSICS OF HIGH PRESSURE. By P. W. Bridgman. International Textbooks of Exact Science. The MacMillan Co., New York, 1931. Cloth, 5¾ × 8¾ in., 398 pp., 87 figs., tables, $5.50.

REVIEWED BY GEORGE B. PEGRAM[3]

HERE is a fascinating book for any one who is interested in the mechanical, thermal, or electrical properties of matter. With a historical introduction, with well-connected discussion of the work of others, historical or current, and with references to most of the important papers in the field, it in the main summarizes the author's own contributions to knowledge in this field. The book is full of quantitative results, yet is easy to read, as might be expected of a book by the author of "The Logic of Modern Physics." After stating that "all this work grew out of the development of a packing technique which makes it possible to reach without leak any pressure allowed by the mechanical strength of the walls of the containing vessels," Professor Bridgman converses about this technique of using packing of the "unsupported area" type for pipe connections and pistons under pressure up to 40,000 kg per sq cm, or about 550,000 lb per sq in., about how such high pressure can be measured, and many other points of technique.

The chapter on "Rupture Peculiar to High Pressures" will be of interest to many engineers. The author is "skeptical as to whether there is any such thing as a genuine criterion of rupture" in terms of elastic or other properties, on account of the extremely varied structure of different sorts of material. He shows rupture of thick steel, of quartz, of glass, the "pinching off" effect with external side pressure on rods, and fails to corroborate the often-quoted result claimed by Amagat, of

[3] Professor of Physics, Columbia University, New York. Mem. A.S.M.E.

forcing mercury through the "pores" of solid steel. Other chapters are on "Compressibility of Solids," "Pressure-Volume-Temperature Relations in Fluids," "The Effect of Pressure on Melting Phenomena," on "Polymorphic Transition," on "Electrical Resistance," on "Thermoelectric Properties," on "Thermal Conductivity," on "Viscosity," and "Miscellaneous Effects of Pressure." In each of these branches of the study of high pressure Professor Bridgman has so widely extended our knowledge that this book will for some time to come be indispensable to any one working in or concerned with the field of high-pressure investigations. It is all the more welcome because there is no other comprehensive book on this subject in any language.

Quality and Quantity in Manufacture

QUANTITY AND ECONOMY IN MANUFACTURE. By Fairfield E. Raymond. McGraw-Hill Book Company, Inc., New York, 1931. Cloth, 6 × 9 in., 375 pp., illus., diagrams, $4.

REVIEWED BY ROBERT T. KENT[4]

THIS book will make heavy reading for the average factory manager or production executive whose acquaintance with mathematics ceased when he left college. Professor Raymond has presented a highly mathematical treatment of the determination of the economical quantity to manufacture at any one time. This mathematical treatment is quite apt to discourage those who have not kept up their mathematics, or who have never gone deeply into the subject.

However, if the reader has the patience and interest to study the book, and to read the explanations that accompany the mathematical treatment, he will soon discover that the subject is not nearly so formidable as one at first glance would be led to believe.

Professor Raymond has developed the general case and included in his general formula all the variables that to date are known to have an influence on the economical manufacturing quantity. He is careful to point out, however, that in a large percentage of the cases which will confront the average factory manager, many of the variables have little or no effect on the final result, and therefore can be neglected. Following this idea, he has presented simplified formulas for a large number of special cases, and has clearly indicated how the factory manager can easily simplify the general formula to fit his own particular case. He has also indicated how the formula can be applied to establish graphs, curves, nomographic charts, slide rules, etc., for the ready application of the principles laid down.

The determination of the economical manufacturing lot is a matter of the utmost importance in industry, and it is gratifying that it has been studied in so thorough a manner as Professor Raymond has done, and the results of these studies put forth in a usable form.

Books Received in the Library

DIESEL REFERENCE GUIDE. By J. Rosbloom. Jersey City, N. J., Industrial Institute, Inc., 1931. 292 pp., illus., diagrs., charts, tables, 8 × 10 in., cloth, $4.

This volume, intended as a reference work for Diesel-engine owners, manufacturers, and operators, brings together in convenient form much practical information. The theory and construction of the engines, their installation and management, accessories, fuels, repairing, and similar topics are discussed, and there are descriptions of locomotives and airplane and automobile engines. Diesel-engine installations in America are listed, and there is a list of the installed engines of over 1000 hp. A section provides a directory of manufacturers of and dealers in engines and accessories.

ENTWICKLUNG DER SCHLEIFTECHNIK. By A. Schroeder. Verlag Petzold-Druck, Hoya-Weser, 1931. Leather, 6 × 9 in., 218 pp., illus., diagrams, maps.

This history of grinding and polishing describes the development of this method of working materials from prehistoric times to the middle of the nineteenth century. A wide field is covered, including the working of wood, metal, glass, stone, gems, and other substances. The methods current at the end of the period are given in detail. Bibliographies for each chapter add to the value of this study of the abrasive industry.

PERSONNEL MANAGEMENT. By W. D. Scott, R. C. Clothier, and S. B. Mathewson. Second edition. New York, McGraw-Hill Book Co., 1931. 583 pp., illus., diagr., charts, tables, 6 × 9 in., cloth, $4.

A comprehensive outline of the principles of personnel management as they are understood and applied today, both to the management of individuals and of groups. The book summarizes the experience of many employers and presents the latest proved findings and accepted methods and policies, making it useful both as a text and for reference. A bibliography is included.

REFRACTORIES. By F. H. Norton. New York, McGraw-Hill Book Co., 1931. 594 pp., illus., diagrs., charts, tables, 6 × 9 in., cloth, $6.

A comprehensive treatise on the manufacture, testing, and properties of refractories. The fundamental processes involved in modern American processes are described. Useful bibliographies accompany each chapter.

ROBERT BOSCH UND SEIN WERK. Im Auftrage des Vereines deutscher Ingenieure, zum siebzigsten Geburtstag von Robert Bosch, herausgegeben von C. Matschoss. Berlin, VDI-Verlag, 1931. 126 pp., illus. diagrs, charts, maps, table, 8 × 12 in., cloth, 8 r.m.

This volume, issued to commemorate the seventieth birthday of Robert Bosch, is not only a biography of the man but an interesting contribution to the history of the gasoline engine and the automobile. Bosch's name is inseparably bound up with the development of electrical equipment for automobiles, and Dr. Matschoss describes his progress from the small electrician's shop in Stuttgart to the great international industries which represent him today.

THE ROEBLINGS: A Century of Engineers, Bridge-Builders, and Industrialists. By H. Schuyler. Princeton, N. J., Princeton University Press, 1931. 425 pp., illus., 6 × 10 in., cloth, $5.

The history of this great family of engineers and bridge builders, from the birth of John A. Roebling to the present time, is here presented in readable, interesting fashion. The story practically begins ninety years ago, when the first crude ropewalk was constructed on Roebling's farm in Saxonburg, near Pittsburgh, and the manufacture of wire rope begun. Succeeding steps, the construction of the first suspension bridges, the removal to Trenton, and the future development of the business are presented. The careers of John A. Roebling's sons, especially Washington A. Roebling, are sketched in full. As the book is primarily for the general reader, the lives and personalities of the men are emphasized rather than the technical details of their bridges, but there still is much to interest the engineer.

[4] Vice-President, Divine Bros. Co., Utica, N. Y. Mem. A.S.M.E.

CURRENT MECHANICAL ENGINEERING LITERATURE

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AIR BRAKES

TESTS. Versuche mit einer neuen Druckluftbremse in Oesterreich (Tests on New Compressed-Air Brakes in Austria), J. Rihosek. V.D.I. Zeit., vol. 75, no. 42, Oct. 17, 1931, pp. 1208–1302, 16 figs. Test results show that present disadvantages of compressed air brakes can be eliminated by addition of sensitive differential relief valve; layout of valves for different train brake systems.

AIRPLANE ENGINES

MANUFACTURE. Machining Parts for Continental Aircraft Engines, B. Finney. Iron Age, vol. 128, no. 23, Dec. 3, 1931, pp. 1418–1421, 6 figs. Steps in machining crankcase, crankshaft, connecting rods, pistons, cylinders, cylinder heads, and other parts of radial-type engine.

SALMSON. The 50 Hp. British Salmson Aero Engine. Flight, vol. 23, no. 45, Nov. 6, 1931, pp. 1100–1104, 10 figs. Design of 9-cylinder radial air-cooled engine of 2.76 by 3.386 in.; developing 55 bhp at 2200 rpm; weight 154 lb.; production methods and tests.

SUPERCHARGING. The Turbo Supercharger, A. L. Berger and O. Chenoweth. Soc. Automotive Engrs.—Jl., vol. 29, no. 4, Oct. 1931, pp. 280–295, 31 figs. History of turbo supercharger, with particular regard to General Electric design, showing progress of supercharger and related airplane parts; study of power required by compressor and power delivered by turbine; list of future developments that may be undertaken to improve supercharger.

Turbo-Compressor and the Supercharging of Aero Engines, F. Whittle. Roy. Aeronautical Soc.—Jl., vol. 35, no. 251, Nov. 1931, pp. 1047–1074, 17 figs. Theory and problems peculiar to supercharging by means of turbo-compressor; general theory of turbo-compressor; methods of drive; comparison of maximum power with height for various types of drive.

AIRPLANES

AIRFOILS TESTING. Aerodynamic Characteristics of Six Commonly Used Airfoils Over Large Range of Positive and Negative Angles of Attack, R. F. Anderson. Nat. Advisory Committee Aeronautics—Tech. Notes, no. 397, Nov. 1931, 5 pp., 6 figs. on supp. plates. For N-22, C-72, Boeing 106, and Goettingen 398 airfoils, negative maximum lift coefficients were found to be approximately half positive; but for M-6 and CVH, which have less effective camber, negative values were, respectively, 0.8 and 0.6 of positive values.

DESIGN. Aufgaben der Luftfahrzeug-Statik (Applications of Aircraft Statics), K. Thalau. Zeit. fuer Flugtechnik und Motorluftschiffahrt, vol. 22, no. 8, Apr. 28, 1931, pp. 229–241, 13 figs. Significance of general statics; special uses of aircraft statics, which is influenced on one hand by different kinds of stresses, and on the other hand by running requirements; structural design and manufacturing methods; bibliography covering problems of airplane statics and strength.

GYROPLANES. See *Gyroplanes*.

PASSENGER—DORNIER. New Dornier Landplane, E. P. A. Heinze. Flight, vol. 23, no. 44, Oct. 30, 1931, pp. 1087–1089, 7 figs. Design and specifications of high-wing cantilever monoplane with four radial air-cooled Czecho-Slovakian Walter "Castor" engines of 240-hp output each; flying weight 13,200 lb; maximum speed of 137 mph; wing span 82 ft; cabin space for 10 passengers.

PERFORMANCE CALCULATION. Comparaison des avions—Abaque des plafonds (Comparison of Airplanes—Chart of Ceilings), J. Kerguistel. Aeronautique, vol. 13, no. 142, Mar. 1931, pp. 89–92, 1 fig. Comparison of different types of airplanes with regard to ceilings, climbing speed; ability of multi-engine planes to operate in case of failure of some engines.

PROPELLERS—HUBS. Spring Hub for Aero-Engines. Aircraft Eng., vol. 3, no. 33, Nov. 1931, pp. 279–280, 4 figs. Design and operation of flexible air-screw drive damping out torque variation which also forms transmission dynamometer, evolved at Royal Aircraft Establishment.

SEAPLANES. See *Seaplanes*.

SPINNING CHARACTERISTICS. Safety in Flight, H. B. Irving and A. V. Stephens. Engineering, vol. 132, no. 3435, Nov. 13, 1931, pp. 614–615. Review of paper on Safety Spinning, before Roy. Aeronautical Soc., bringing out value of model experiments in revealing structural features of importance in spinning and providing rational basis for anti-spinning design.

WINGS—SLOTTED. Aerodynamic Characteristics of Slotted Clark Y-Wing As Affected by Auxiliary Airfoil Position, C. J. Wenzinger and J. A. Shortal. Nat. Advisory Committee Aeronautics—Report, no. 400, 1931, 16 pp., 31 figs. Aerodynamic force tests on slotted Clark Y-wing conducted in vertical wind tunnel; increase of 41.5 per cent in maximum lift; angle of attack for maximum lift increased 13 deg; maximum increase of about 30 deg possible in highest stalling angle.

AIRSHIPS

MILITARY—Z.R.S. 4. Latest Rigid Airship. Aircraft Eng., vol. 3, no. 33, Nov. 1931, pp. 271–273, 7 figs. Construction and specifications of Goodyear-Zeppelin Akron built for U. S. Navy; gas volume 6,500,000 cu ft; length o.a. 785 ft; maximum diam. 132 ft 11 in.; gross lift 180 tons (helium); tare weight 99 tons; useful lift 81 tons; total hp, 4480.

ALLOYS

ALUMINUM. See *Aluminum Alloys*.

NICKEL. See *Automobiles—Materials*.

ALUMINUM

ALUMINUM SHEET. Forming of Aluminum Alloy Sheet for Aircraft, F. V. Hartman and G. O. Hoglund. Aviation Eng., vol. 5, no. 4, Nov. 1931, pp. 36, 38 and 40, 6 figs. Methods of forming and stamping with particular regard to precautions as to effect of cold work and heat treatment; typical tensile properties of wrought aluminum alloys; approximate radii for 180-deg cold bend of aluminum and aluminum-alloy sheet.

ALUMINUM ALLOYS

CORROSION. Methods for Determining Corrosion Resistance of Aluminum and Aluminum Alloys. Indus. Chemist, vol. 7, no. 80, Sept. 1931, pp. 378–380, 2 figs. Tentative standards elaborated by Aluminum Board of German Reichausschuss fuer Metallschutz; taking test specimens from sample sheet; preliminary treatment of specimens; evaluation of results; special directions for performance of tests.

TEMPERATURE EFFECTS. Thermal Expansion of Some Aluminum Alloys, E. E. McCollough. Physics, vol. 1, no. 5, Nov. 1931, pp. 334–339. Effect of varying per cent of given alloying element and comparison of effects of different alloying elements; aluminum-copper, aluminum-iron, aluminum-magnesium, aluminum-nickel, aluminum-silicon, and aluminum-manganese were investigated.

AUTOMOBILE ENGINES

FUEL ECONOMY. Brennstoffregler und Vergaserzusatzapparate (Fuel Regulators and Auxiliary Devices for Carburetors), H. Rohrbach. Duetsche Motor-Zeit., vol. 8, no. 10, Oct. 1931, pp. 356–358 and 360. Critical survey of possibility of effecting saving by employing special fuels or changes in carburetion.

MANUFACTURE. Motor-Car Cylinder Block Production. Machy. (Lond.), vol. 39, no. 994, Oct. 29, 1931, pp. 129–134, 13 figs. Boring, milling, and drilling operations in shops of Riley, Ltd., Coventry; data on output and tolerances.

Production of Motor-car Connecting Rods. Machy. (Lond.), vol. 39, no. 995, Nov. 5, 1931, pp. 161–164, 11 figs. Index drilling, continuous milling, and die-casting operations in plant of Riley (Coventry), Ltd.; data on speed, feed and tolerances.

TURBINES—SULPHUR DIOXIDE. The Automobile Turbine, C. Cukor. Automobile Engr., vol. 21, no. 285, Oct. 1931, p. 415. Advantages of sulphur-dioxide turbine system for automotive purposes; uniform torque, simplified lubrication, low combustion temperature, minimum of wearing parts, and extreme low cost of manufacture; turbine impeller on 100-hp turbine less than 8 in. diam.; constructional drawings show that car contains only about 8 per cent of machine parts of conventional automobile.

AUTOMOBILES

BRAKES—TESTING. Pruefung der Bremswerke von Kraftfahrzeugen (Testing of Brakes of Motor Vehicles), H. J. Venediger. Automobiltechnische Zeit., vol. 34, no. 31, Nov. 10, 1931, pp. 703–705, 1 fig. Theoretical braking distance; static friction; ideal 4-wheel brake; error of observation in experimental determination of braking distance.

CLUTCHES. Abolishing Clutch Pedal. Motor (Lond.), vol. 60, no. 1559, Nov. 10, 1931, pp. 709–711, 7 figs. Development of automatic clutches illustrated by representative designs including vacuum control, fluid flywheel, and hydraulic control.

FRAMES—WELDING. Welding of Frames May Introduce Greater Chassis Rigidity and Effect Production Economies, A. F. Denham. Automotive Industries, vol. 65, no. 21, Nov. 21, 1931, pp. 788–790 and 798, 2 figs. Advantages of welded over riveted construction; use of thinner stock and elimination of side rails.

FRONT-WHEEL DRIVE. Der achslose 2.5-Liter - Brennabor - Vorderradantrieb (2.5 - Liter-Brennabor Front-Wheel Drive Without Axle), G. Prachtl. Automobiltechnische Zeit., vol. 34, no. 29, Oct. 20, 1931, pp. 661–662, 4 figs. New features of 4-, 6-, and 8-cylinder models.

MANUFACTURE—PRODUCTION CONTROL. Die Aufstellung von einem Fabrikationsprogramm fuer eine Automobilfabrik mit einer Belegschaft von 3000 Mann (Production Program for Automobile Plant With 3000 Employees), R. Koch. Automobile-Rundschau, vol. 33, no. 20, Oct. 20, 1931, pp. 403–406. Practical example illustrates method of organizing production; ordering and handling of materials; cost calculation; productive and unproductive wages; distribution of overhead.

MATERIALS—NICKEL ALLOYS. Nickel Alloys in Automotive Manufacture, T. H. Wickenden. Soc. Automotive Engrs.—Jl., vol. 29, no. 4, Oct. 1931, pp. 328–330 and (discussion) 330–331, 3 figs. Cylinders, cylinder heads, pistons, exhaust manifolds, and brake drums among chief engine and automobile parts in which nickel cast iron is used; discussion concerned with experiences with use and heat-treatment of nickel-iron.

RATING. Personenwagenbewertung (Rating of Passenger Cars), E. Falz. Automobiltechnische Zeit., vol. 34, no. 28, Oct. 10, 1931, pp. 629–630. Combination of desirable features of cars into figure of merit, with particular regard to hill-climbing ability, investment per seat, and fuel consumption.

SPRINGS AND SUSPENSION. Le stabilisateur repusseau (Repusseau Stabilizer), R. Charles-Faroux. Vie Automobile, vol. 27, no. 979, Oct. 10, 1931, pp. 531–532, 4 figs. Operating principles and design of stabilizing device developed for purpose of maintaining even load distribution in turning corners and curves.

TRANSMISSIONS—HYDRAULIC. Leyland Introduces a Fluid Transmission. Motor Transport, vol. 53, no. 1392, Nov. 16, 1931, p. 641, 1 fig. Device incorporating rotary pump driven by flywheel, and throwing fluid on to blades of turbine, thereby transmitting energy from driving to driven member; "gear ratio" adjusting itself to load and engine speed.

B

BALANCING MACHINES

STATIC—DYNAMIC. Eine neue statisch-dynamische Auswuchtmaschine (New Static Dynamic Balancing Machine), W. Reichel. Maschinenbau, vol. 10, no. 18, Sept. 17, 1931, pp. 593–595, 18 figs. Design and operating principles of balancing machines, Trebel system; example illustrates time saving.

BEARINGS

FRICTION. Friction of Pivots and Journals. Machy. (Lond.), vol. 39, no. 995, Oct. 29, 1931, pp. 142–144, 7 figs. Mathematical investigation of conditions obtaining in flat, conical, truncated conical, hemispherical, and Schiele pivots and journals.

BLAST FURNACES

OPERATION. Blast Furance and the Foundry, R. A. Haching. Foundry Trade Jl., vol. 45, no. 795, Nov. 12, 1931, p. 302. Data concerning effects of hot and cold blast and dry air in blast-furnace operations; factors governing carbon and silicon contents. Before Inst. Brit. Foundrymen.

BOLTS AND NUTS

FORGING. New Nut-Forging Machine. Engineer, vol. 152, no. 3957, Nov. 13, 1931, p. 515, 4 figs. Machine for making blanks for "black" nuts, which suggests that considerable saving may be made in amount of scrap ordinarily produced by Oliver machine; it is invention of H. Maplethorpe; process consists in pressing hot cylindrical blank out into salient angles of hexagonal die and punching central hole, in series of five operations.

BOILERS

CONTROL. Betriebsergebnisse mit automatischer Feuerungsregelung an Rost- und Staubkesseln (Experiences With Automatic Control of Stoker-Fired and Pulverized-Coal Boilers), C. Himmler. Waerme, vol. 54, nos. 46 and 47, Nov. 14, 1931, pp. 850–852, Nov. 21, pp. 863–867, 15 figs. In connection with problem of automatic equalization of load fluctuations of peak-load boiler, most common types of electric boiler control were investigated; advantages of combined remote and automatic control.

Das Brennkammerschaubild (Combustion-Chamber Diagram), K. G. Voswinckel and F. Rosendahl. Waerme, vol. 54, no. 44, Oct. 31, 1931, pp. 817–818, 2 figs. Chart developed by authors and its applications.

DESIGN. Hilfsmittel zur Beurteilung von Brennkammerbauarten (Rules for Evaluation of Combustion-Chamber Designs), R. Barth. Archiv fuer Waermewirtschaft, vol. 12, no. 11, Nov. 1931, pp. 335–336, 11 figs. Graphic method is developed, with aid of which it is possible to separate parts of heating surface by masonry sections, and to determine approximately influence of angle ratio of grate to heating surface and also distribution of evaporation over length of bottom boiler-tube nest.

Modern Practice in Cylindrical Boilers. Eng. and Boiler House Rev., vol. 45, no. 4, Oct. 1931, pp. 226, 228, 230 232 and 234, 7 figs. Outline of developments in design of various types of cylindrical boilers; return-tube and dry-back boilers; vertical cross-tube and water-tube boilers; waste-heat boilers; steam accumulators.

FIRING. Tangential Firing of Gaseous and Liquid Fuels, O. de Lorenzi. Combustion, vol. 3, no. 4, Oct. 1931, pp. 11–15 and 21, 4 figs. Development of tangential firing with particular reference to use in connection with blast-furnace gas; several installations are described and data given on results obtained; method of firing equally suitable for gaseous and liquid fuel and possesses marked flexibility in that it permits burning of any combination of these fuels simultaneously in same furnace.

MANUFACTURE—WELDING. Zur Metallurgie der Schweissung von Stahl, mit besonderer Berueecksfichtigung des Dampfkesselbaus (Metallurgy of Steel Welding With Particular Regard to Steam Boiler Manufacture), A. Fry. Kruppsche Monatshefte, vol. 12, Aug.-Sept. 1931, pp. 201–214, 22 figs. Advantages of different welding methods including oxyacetylene and electric arc welding, Arcatom and Arcogen; effect of welding methods and heat treatment on physical properties of steel; testing methods and test results. Bibliography.

PLATES—TEMPERATURE EFFECT. Berechnungswerte der Kesselbaustoffe bei hoeheren Temperaturen (Calculated Values of Boiler Materials at Elevated Temperatures), P. Fischer. Kruppsche Monatshefte, vol. 12, Oct. 1931, pp. 267–268. Tabular data on properties of boiler plates at elevated temperatures, compiled and presented as aid to designer in his calculations.

PULVERIZED-COAL—ASH REMOVAL. Die Aschenschmelzkammer (Fluxing of Ashes in Slagging-Type Furnace), Boie. Waerme, vol. 54, no. 45, Nov. 7, 1931, pp. 828–830, 4 figs. Contribution to coal-ash problem; development of pulverized-coal firing is to great extent depending on solution of ash-removal problem; American experiences with slag-tap furnaces; possibilities of future development.

TESTING. Boilers at Clyde's Mill Power Station. Engineer, vol. 152, no. 3958, Nov. 20, 1931, pp. 551–553, 3 figs. Report of Strain and Robertson, Glasgow, on results of exhaustive tests of new boiler plant; installation comprises four cross-drum boilers of 400-lb pressure, each equipped with chain-grate stokers; methods of measurement employed; record of test measurements and results.

TUBES—RIBBED. Versuche ueber die Waermeabgabe von Rippenrohren (Tests on Heat Discharge of Ribbed Tubes). E. Schmidt and W. Hindenburg. Archiv fuer Waermewirtschaft, vol. 12, no. 11, Nov. 1931, pp. 327–333, 11 figs. Measurements of heat efficiency in relation to excess temperature on 25 ribbed tubes of different design; great difference shown in heat-transfer coefficient; formulas are developed and rules set up for standardization and testing of ribbed tubes.

C

CAMS

DESIGN. Modified Gravity Curves for Quick-Acting Cams, K. G. Holst. Am. Mach., vol. 75, no. 21, Nov. 19, 1931, pp. 775–777, 5 figs. Design and calculation of cams in which acceleration increases uniformly from zero (cube-curve acceleration) during first fifth of acceleration period and decreases uniformally to zero in last fifth.

CARBURETORS

ATOMIZATION IN. On Atomization in Carburetors, F. N. Scheubel. Nat. Advisory Committee for Aeronautics—Tech. Memo., no. 644, Oct. 1931, 11 pp., 31 figs. partly on supp. plates. Study of atomization in carburetors in Aerodynamic Institute of Technical University at Aachen; alcohol and water were liquids studied. From Jahrbuch der Wissenschaftlichen Gesellschaft fuer Luftfahrt, 1927.

CARS, PASSENGER

AIR CONDITIONING. Three Air-Conditioned Trains Operated by Baltimore and Ohio. Ry. Age, vol. 91, no. 18, Oct. 31, 1931, pp. 675–676. "Columbian" and "New York-Washington Express" composed entirely of air-conditioned cars; parlor cars operated between New York and Washington on "New York-Cincinnati-St. Louis Express;" operation of York system; cooling and distribution of air; power supply, and control.

CAST IRON

AUSTENITIC. Austenitic Cast Irons, J. E. Hurst. Foundry Trade Jl., vol. 45, no. 791, Oct. 15, 1931, pp. 237–239, 7 figs. Properties of type of austenitic cast iron cast by centrifugal process and containing varying quantities of chromium were examined; with increasing quantities of chromium material becomes harder.

DEFECTS. Sur le phénomène improprement appelé "trempe inverse de la fonte" (Phenomenon Incorrectly Termed "Inverse Chilling of Cast Iron"), L. F. C. Girardet. Revue de Fonderie Moderne, vol. 25, Oct. 10, 1931, pp. 359–361, 3 figs.; see also Foundry Trade Jl., vol. 45, no. 796, Nov. 19, 1931, p. 319, 2 figs. In author's belief, inverse chilling is not due to chilling but to inclusions of white iron which have penetrated in liquid form into mold and have not dissolved in molten gray iron.

LOW-CARBON. Low Total-Carbon Cast Irons and their Service to Foundrymen, W. West. Foundry Trade Jl., vol. 45, no. 793, Oct. 29, 1931, pp. 272–275, 8 figs. Use of low-total-carbon irons is seriously discountenanced by difficulties encountered in foundry practice; where high-test irons are necessity, then advantages gained outweigh other foundry disadvantages. Before Inst. Brit. Foundrymen.

NICKEL. Nickel Cast Iron in Automobile Industry. Foundry Trade Jl., vol. 45, no. 793, Oct. 29, 1931, pp. 267–271, 8 figs. Limitations of cast iron; nickel in cast iron; automobile cylinder blocks and heads; problem of cylinder wear; air-cooled, cylinders; cylinder liners; special hard liners; heat-treated liners; piston rings and pistons; valve seats and valve guides; tappets; brake drums, etc.

CASTINGS

DESIGN. Einfluss der Konstruktion von Gusstuecken auf den Herstellungspreis (Effect of Design of Castings on Production Costs), H. Tillmann. Maschinenbau, vol. 10, no. 16, Aug. 20, 1931, pp. 525–529, 55 figs. Practical examples illustrate possibilities of saving by correct design with particular regard to cost of patterns; benefits of standardization.

CHROMIUM-MOLYBDENUM STEEL

WELDING. Untersuchungen ueber die Gasschmelzschweissbarkeit, etc. (Investigations on Oxyacetylene Welding of Chromium Molybdenum Alloyed Steel for Airplane Construction), K. L. Zeyen. Kruppsche Monatshefte, vol. 12, Aug.-Sept. 1931, pp. 214–223. Principal literature, particularly American and German sources; test-results obtained at Krupp Laboratories; strength properties, chemical composition, hardness, deep drawing and fatigue characteristics, etc.

COAL CARBONIZATION

LOW-TEMPERATURE. Das Babcock-Verfahren fuer Schwelkraftwerke (Babcock System of Com-

bined Power and Coal Carbonization Plant). V.D.I. Velani. Brennstoff-und Waermewirtschaft, vol. 13, no. 10, Oct. 1931, pp. 183–185, 4 figs. Low-temperature carbonization of lignite for recovery of tar and utilization of semi-coke for generation of electric power.

Low-Temperature Carbonisation. Colliery Guardian, vol. 143, no. 3694, Oct. 16, 1931, pp. 1300–1301, 1 fig.; see also Iron and Coal Trades Rev., vol. 123, no. 3320, Oct. 16, 1931, p. 584. Report of tests by Director of Fuel Research on plant of Leicestershire (L. and N.) Coal Distillation Co., Ltd., at Newbold, November 24 to 29, 1930.

Salerni System of Low-Temperature Carbonisation, R. V. Wheeler. Colliery Guardian, vol. 143, no. 3699, Nov. 20, 1931, pp. 1715–1717. System devised by Pierno Salerni; retort is of rotary-drum type; essence of process is blending with percentage of semi-coke, from process itself, with coal to be treated; advantages of system; Salermo retort, for production of powdered semi-coke, was designed by Eldorsado Salerni, a brother. Before Int. Conference Bituminous Coal.

CONVEYORS

CONTROL. On and Off Up and Down Automatically, R. G. Lockett. Maintenance Eng., vol. 89, no. 10, Oct. 1931, pp. 491–494, 7 figs. Design, construction, and operating details of automatic vertical conveyor; electric control features.

COOLING TOWERS

DESIGN. Cooling Tower Design and Performance, H. R. Lamberth. Petroleum World (Los Angeles), vol. 28, no. 10, Oct. 1931, pp. 31–33 and 58, 5 figs. Definitions of dry bulb temperature, wet bulb temperature, dew point, and relative humidity; examples of relationships; cooling tower performance curves; important factors of design; mechanical details of design are not considered.

CRANES

LUFFING. Die neueren Einziehkrane mit waagerechter Lastbahn (Modern Luffing Cranes With Horizontal Path of Load), G. Bethmann. Maschinenkonstrukteur, vol. 64, no. 19–20, Oct. 10, 1931, pp. 201–204, 9 figs. Diagrammatic representation of mechanism of various German makes.

CRANKSHAFTS

FORCES ACTING ON. Die Kraefte an der Kurbelwelle (Forces Acting on Crankshaft), K. Herr. Automobiltechnische Zeit., vol. 34, nos. 27, 28, and 30, Sept. 30, 1931, pp. 604–606, Oct. 10, pp. 631–634, and Oct. 31, pp. 688–690, 10 figs. Determination of forces in various points of cycle, with particular regard to graphical methods; relative importance of factors controlling bearing pressure and dimensions.

VIBRATIONS. Vibration Characteristics of Aircraft Engine Crankshafts. War Dept. Air Corps, Material Division—Air Corps Tech. Report, no. 3533, Oct. 2, 1931, 59 pp., 22 figs. Development and application of instrument for recording torsional vibrations; test results with various makes and types of engines; calculation of frequency of vibration from drawings.

CUPOLAS

PRACTICE. Kann niedriggekohltes Gusseisen im Kupolofen hergestellt werden? (Possibility of Producing Low-Carbon Cast Iron in Cupolas), Kalpers. Zeit. fuer die gesamte Geissereipraxis, vol. 52, no. 44, Nov. 1, 1931, pp. 371–373. Two methods considered: use of mixture with large amount of steel scrap, or use of special pig iron for cupola; former method is cheaper; manufacture of low-carbon pearlitic cast iron by Brown-Boveri process.

Metallurgische Beitraege zur Kenntnis der Kupolofenvergaenge (Study of Cupola Processes), B. Osann, Jr. Giesserei, vol. 18, nos. 42, 43 and 45, Oct. 16, 1931, pp. 800–818, Oct. 23, pp. 827–835, and Nov. 6, pp. 859–866, 30 figs. partly on supp. plates. Mechanism of furnace process; time required for passage of iron through furnace and its influence on melting; metallurgical phenomena before, during, and after melting in cupola; melting in electric crucible furnace.

Tests Value of Soaking Cupola Charges, W. H. Spencer and M. M. Walding. Foundry, vol. 59, no. 22, Nov. 15, 1931, pp. 26–27. Experiments with different cupolas, charges, and blast pressures lead to conclusion that while no especially beneficial results obtained from soaking charges, melting rate, as shown by time required to melt given amount of iron, tends to be lower with longer soaking periods. Before Am. Foundrymen's Assn.

CYLINDERS

STIFFENERS. Berechnung der Ringversteifungen duennwandiger Hohlzylinder (Design of Annular Stiffeners for Thin-Walled Hollow Cylinders), K. Pohl. Stahlbau (Supp. to Bautechnik), vol. 4, no. 14, July 10, 1931, pp. 157–163, 24 figs. Theoretical mathematical discussion making use of method of influence lines.

D

DIES

MANUFACTURE. Incentive Applied to Die Making, E. E. Clark. Am. Mach., vol. 75, no. 21, Nov. 19, 1931, pp. 771–774, 5 figs. Practical examples illustrate general plan for application of standard time to die making, suitable for die shop working from 50 to 300 die makers.

DIESEL ENGINES

AUTOMOTIVE. Progress of Oil Engine. Commercial Motor, vol. 54, no. 1391, Nov. 10, 1931, pp. 438–439, 1 fig. Development of Saurer 4-cylinder unit of 100 mm bore and 130 mm stroke, with maximum power of 55 bhp at 2400 rpm.

The Oil Engine—Today and To-Morrow. Commercial Motor, vol. 54, no. 1390, Nov. 3, 1931, pp. 382–385, 11 figs. Tendencies in development and outlook for future; merits of high-speed and moderate-speed engines; characteristics of representative British makes including Crossley, Gardiner, Thornycroft, Dennis and A. E. C.

Zwei neue Maybach-Einspritzdieselmotoren (Two New Maybach Diesel Engines), A. E. Thiemann. Automobiltechnische Zeit., vol. 34, no. 29, Oct. 20, pp. 659–660, 6 figs. Design and performance data of 6-cylinder and 12-cylinder V engines with solid injection; bore and stroke 140 by 180, and 150 by 200, respectively; 150 hp. at 1400, and 410 hp at 1400 rpm, respectively.

FUEL INJECTION. Some Characteristics of Fuel Sprays at Low-Injection Pressures, A. M. Rothrock and C. D. Waldron. Nat. Advisory Committee Aeronautics—Tech. Note, no. 399, Nov. 1931, 6 pp., 9 figs. on supp. plates. Sprays from 0.008-in. and 0.020-in. open nozzle; injection pressures from 100–500 lb per sq in.; fuel oil and gasoline were injected into air at densities of atmospheric and 0.325 lb per cu ft.

HIGH-SPEED. Performance of Compression-Ignition Engines With Precombustion Chamber Having High-Velocity Air Flow, J. A. Spanogle and C. S. Moore. Nat. Advisory Committee Aeronautics—Tech. Note, no. 396, Oct. 1931, 15 pp., 15 figs. on supp. plates. Experiments on single-cylinder 4-cycle engines with two pre combustion chambers, pear-shaped and spherical type; low-pressure injection from large round-hole nozzle; head capable of operating at 4000 rpm.

Schnellaufende Dieselmotoren (High-Speed Diesel Engines), W. Laudahn. Glasers Annalen, vol. 109, no. 8, Oct. 15, 1931, pp. 69–75, 10 figs. Balancing of masses and damping of vibrations; friction dampers by MAN and Maybach; hydraulic damper by Sandner and Junkers; superchargers by Zoller and Lorenzen.

HEAT LOSSES. Répartition théorique approximative des pertes de chaleur par les parois d'un moteur Diesel (Heat-Loss Distribution in Diesel-Engine Cylinder Walls), Gautier. Bul. Technique du Bureau Veritas, vol. 13, no. 9, Sept. 1931, pp. 178–181, 7 figs. Theoretical study based on Nusselt theory, and results of temperature measurements by method proposed by Sulzer; for piston and cylinder head, cooling losses up to maximum temperature point of cycle, are half total for cycle, while for jacket, loss is one-quarter of total.

MANUFACTURE. Machining Operations on Connecting Rods, Pistons and Crankshafts for Heavy Oil Engines—II. Machy. (Lond.), vol. 39, no. 993, Oct. 22, 1931, pp. 97–100, 10 figs. Bullard vertical turning and boring mill machining cylinder heads; adjustable fixture for face milling connecting rod bosses; 22-in. swing combination turret lathe; elliptic turning and boring lathe for piston-ring pots; centering and marking out crankshafts; machining side faces of crank-webs on double traversing-head shaping machine.

MARINE. Entwicklung der Spuelung fuer Zweitakt-Dieselmaschinen, etc. (Development of Scavenging for Two-Cycle Diesel Engines With Particular Regard to Work at Germania Shipyards), K. Mohr. Kruppsche Monatshefte, vol. 12, Aug.-Sept. 1931, pp. 230–236, 8 figs. Successful application of port scavenging protected by German patents 514456–527200; fuel consumption of eight engines on standard oil tanker is 136 g per indicated hp-hr at 5.6 atm mep.

PERFORMANCE. Leistungs- und Brennstoffverbrauchsversuche an Dieselmaschinen (Performance and Fuel-Consumption Tests of Diesel Engines). Zeit. des Bayerischen Revisions-Vereins, vol. 35, no. 21, Nov. 15, 1931, pp. 257–259. Results of tests carried out in 1929 and 1930.

DYNAMOMETERS

IMPROVED FROUDE. New Dynamometer. Automobile Engr., vol. 21, no. 287, Nov. 1931, p. 531, 2 figs. "Froude" hydraulic dynamometer in which all vanes remain effective irrespective of load or speed; standardized in capacities up to 4500 bhp at 1000 to 3500 rpm.

E

ECONOMIZERS

ROTARY. Umlaufende Speisewasservorwaermer (Rotary Feedwater Preheaters), M. Grandl. Waerme, vol. 54, no. 47, Nov. 21, 1931, pp. 859–862, 7 figs. Design and advantages of rotary economizers, especially for high-pressure boiler plants; use of high-quality material is essential; heat transfer and gas velocity, and power consumption of rotary economizers, operating results; costs.

ELASTICITY

MODULUS—DETERMINATION. Ueber die Bestimmung des Elastizitaetsmoduls von Staeben mit Hilfe von Biegungsschwingungen (Determination of Modulus of Elasticity of Rods by Means of Flexural Vibrations), E. Goens. Annalen der Physik, vol. 11, no. 6, 1931, pp. 649–678, 2 figs. Outline of theory of flexural vibrations of rods after Rayleigh and Timoshenko; experimental tests of theory, made at Institute of Engineering Physics of Germany.

ELECTRIC FURNACES

ELECTRODES. Ausmasse, Belastung, Reglung und Verbrauch der Elektroden der Lichtbogenoefen zum Schmelzen von Grauguss und Stahl (Electrodes of Arc Furnaces for Melting Gray Iron and Steel), E. Kothny. Giesserei, vol. 18, no. 46, Nov. 18, 1931, pp. 873–878. Design, average load, regulation and handling of electrodes; graphite, carbon and Soderberg electrodes; ideal and actual electrode requirements under different conditions.

ROCKING. Detroit Rocking Electric Furnace, C. H. Morken. Am. Electro-chem. Soc.—Trans., vol. 58, 1930, pp. 327–338, 1 fig. It is shown how furnace is used for smelting and processing gray iron; operation data and costs are given with properties of iron; rocking action of furnace has marked effect upon properties of iron; high test gray iron can be produced at costs below those of cupola iron.

ELECTRIC WELDING ARC

ATOMIC HYDROGEN. Das Arcatom-Schweissverfahren (Arcatom Welding Method), S. Sandelowsky. V. D. I. Zeit., vol. 75, no. 44, Oct. 31, 1931, pp. 1361–1364, 11 figs. Electric arc welding in protecting atmosphere of dissociated hydrogen according to Langmuir.

ELECTRODES. De verbranding van de elementen uit de laschdraad en de opname van stikstof uit de lucht bij het lichtbooglasschen (Combustion of Elements in Welding Rods and Absorption of Oxygen From Air in Arc Welding), P. Schoenmaker. Polytechnisch Weekblad, vol. 25, no. 41, Oct. 8, 1931, pp. 647–648, 3 figs. Testing and analysis of electrodes of three different compositions, results in tables.

ELECTRIC WELDING, RESISTANCE

SPOT WELDING. Control of Spot and Flash Welds, G. A. Hughes. Welding Engr., vol. 16, no. 7, July 1931, pp. 33–36, 6 figs. Electrical characteristics of equipment and tests show results obtained in resistance welding; summary of tests on resistance butt-welded joints; Lehigh University welding symposiums; comparative Brinell and Rockwell hardness tests made on resistance welds in low carbon steel. Before Assn. Iron and Steel Elec. Engrs.

F

FLOW OF FLUIDS

MEASUREMENT. Formeln, Beisplele und Unterlagen zur Berechnung durchfliessender

Mengen (Formulas and Data for Calculation of Flow), H. Euler. Archiv fuer das Eisenhuettenwesen, vol. 5, no. 5, Nov. 1931, pp. 231–249, 11 figs. Results of latest tests and reports; compilation of flow formulas for diaphragms (gas, air, steam, water), and for venturi tubes; rule-of-thumb formulas; Reynolds' coefficient; examples of calculation of blast-furnace gas, steam, and water flow.

FLOW OF LIQUIDS

CAPILLARY. Capillary Conduction of Liquids through Porous Mediums, L. A. Richards. Physics, vol. 1, no. 5, Nov. 1931, pp. 318–333, 5 figs. Hydrodynamic laws of flow of liquids in unsaturated porous mediums; capillary conduction of water through soil and clay; hysteresis effect between capillary potential and moisture content of porous medium; forces affecting capillary action; experiments with capillary conduction.

FLUE GASES

SPECIFIC HEAT. Specific Heat of Flue Gases. Combustion, vol. 3, no. 4, Oct. 1931, pp. 44–45, 2 figs. Composition of flue gas for various fuels; mean specific heat above 70 F of flue-gas constituents; chart showing mean specific heat of flue gases from various fuels.

FORGINGS, STEEL

BEHAVIOR IN FURNACES. Influence of atmosphere and Temperature on Behavior of Steel in Forging Furnaces, D. W. Murphy and W. E. Joming. Univ. Mich.—Eng. Research—Bul., no. 21, Oct. 1931, 148 pp., 63 figs. $1.00. Burning and overheating; relation of burning point to iron-carbon diagram; effect of forging treatment; temperature distribution in steel sections; scaling of steel at forging temperatures; mechanism of continued oxidation; effects of sulphur in combustion gases.

FOUNDRIES

ELECTRIC MELTING. Operating Iron Foundry Without Pig-Iron, W. Lister. Foundry Trade Jl., vol. 45, no. 795, Nov. 12, 1931, p. 305. It is claimed that, without using a pound of pig iron, better quality of gray iron can be produced in electric furnace than from that of cupola and at cost equal, if not lower, than that of cupola product and greater output is obtained from same floor space.

PULVERIZED COAL IN. Pulverised Fuel in Foundry Industry, W. Boon. Colliery Guardian, vol. 143, no. 3696, Oct. 30, 1931, pp. 1489–1490. Desirability of fine grinding; ratio of fuel to metal; application of pulverized-fuel firing to different types of melting furnaces; effect of pulverized-fuel firing upon furnace refractories. Before Inst. Brit. Foundrymen.

TEMPERATURE MEASUREMENT. La mesure des températures in fonderie (Measurement of Temperatures in Foundries), Clain. Revue de Fonderie Moderne, vol. 25, Oct. 10, 1931, pp. 363–365, 5 figs. Design and application of thermoelectric and optical pyrometers.

G

GAGES

PRECISION TYPES. Precision Measuring Instruments, O. P. Van Steewen. Am. Mach., vol. 75, nos. 18 and 19, Oct. 29 and Nov. 5, 1931, pp. 666–668 and 704–707, 22 figs. Oct. 29: Saddle gage for checking rolls for camber; Mikrostat saddle gage for small objects such as fluted reamers, and taps; combination height and diameter gage for pistons; device for checking taper on pins or rollers; testing bevel gears on Zeiss tester. Nov. 5: Glass indexing plate with astronomical angular marking, for dividing heads, gears, cams, etc.; portable thread-profile gage that can be used before threaded part is finished; micrometer head used in conjunction with thread-center-distance setting device; optical bevel protractor.

GASOLINE ENGINES

PISTONS. Piston Design for Gasoline Engines, H. A. Heubotter. Motive Power, vol. 2, no. 10, Oct. 1931, pp. 9–14 and 42, 3 figs. Having stated desirable objectives of piston design for gasoline engines, practical design of two types of pistons is presented with discussion of advantages and disadvantages of gray-iron and aluminum alloys as materials of construction and mathematical analysis of piston temperature.

GEARS

DESIGN. Tip Relief of Gear Teeth Prevents Gouging and Scraping, T. R. Rideout. Automotive Industries, vol. 65, no. 19, Nov. 7, 1931, pp. 718–722, 11 figs. Different types of interference and remedies by means of tip relief; interference by deflection of teeth and by compression at point of contact; forms of corrections for generating tools and tip relief produced by them; error in gear-tooth spacing. Before Am. Gear Mfrs. Assn.

LOAD CAPACITY. How Much Power Should Gears Transmit? E. Buckingham. Machy. (N. Y.), vol. 38, no. 2, Oct. 1931, pp. 81–87, 3 figs. Limiting static tooth load or strength of tooth considered merely as beam; maximum load capacity as limited by tooth wear; maximum dynamic load and its relation to applied load; example showing comparison of dynamic load and static beam strength.

LUBRICATION. Hypoid Rear Axle Gears Call for "Extreme Pressure" Lubricants, H. C. Mougey and J. O. Almen. Automotive Industries, vol. 65, no. 20, Nov. 14, 1931, pp. 758–761, 6 figs. Series of experiments made at General Motors Laboratories show how these lubricants operate and throw light on effects of sulphur in lead-soap lubricants and acids in castor oil; dichlarethyl in lubricant.

WORM GEARS—CUTTING. Worm Gear Generation, F. W. Shaw. Am. Mach., vol. 75, no. 19, Nov. 5, 1931, pp. 701–703, 4 figs. Method of relieving tangential cutters effects surprising gains in production; gears of 22 teeth, 1-in. circular pitch, 1¹/₈-in. face, of phosphor bronze generated in 5 min; for cast-iron gears time was 3 min.

Gewindebearbeitung auf Raeder-Waelzfraesmaschinen (Thread Cutting on Milling Machines), K. Glaeser. Maschinenbau, vol. 10, no. 16, Aug. 20, 1931, pp. 532–534, 3 figs. Practical example illustrates thread milling procedure in making worms for automobile drive, automobile steering gears, and phonographs.

GRINDING

SURFACE. Accurate Surface-Grinding of Castings. Machy. (N. Y.), vol. 38, no. 2, Oct. 1931, pp. 122–123, 5 figs. Typical examples of production jobs handled on vertical surface-grinding machines, built by Blanchard Machine Co., Cambridge, Mass.; data on tolerances for automobile cylinder block and for gasoline meter.

GYROPLANES

WILFORD. Aerodynamics of the Wilford Gyroplane With Special Reference to Maximum Lift Coefficients, A. Klemin and B. P. Ruffner. Aviation Eng., vol. 6, no. 2, Aug. 1931, pp. 7–10 and 16, 8 figs. Tests at New York University on new type of rotating air-foil system, invented by Walter Kreiser and Walter Rieseler, and developed by E. Burke Wilford of Pennsylvania Aircraft Syndicates.

H

HEAT-INSULATING MATERIALS

QUALITY AND EFFICIENCY. Mesure de la qualité isolante determination de l'économie résultant de leur emploi (Heat-Insulating Materials; Measurement of Their Insulating Qualities and Determination of Economy Resulting From Their Use), deM. Weyer. Associations Françaises de Propriétaires d'Appareils à Vapeur—Bul., vol. 12, no. 45, July 1931, pp. 141–159, 3 figs. Theoretical mathematical design analysis; results of tests in tables and curves.

HEAT STORAGE

PRINCIPLES. Thermal Storage—I and II, E. G. Ritchie. Steam Engr., vol. 1, nos. 1 and 2, Oct. 1931, pp. 18–19 and 20, Nov., pp. 66–68, 4 figs. First of series of articles dealing with whole field of steam and heat storage; fluctuating loads and their economic results; curves and tables illustrating pressure and steam flow fluctuations.

HEAT TRANSMISSION

ECONOMIZERS. Étude aérodynamique et nomographique de quelques problèmes thermiques—II (Aerodynamic and Nomographi, Study of Some Thermodynamic Problems), W. Margoulis. Chaleur et Industrie, vol. 12-no. 137, Sept. 1931, pp. 471–482, 3 figs. Nomographic study of heat transmission with particular regard to application to economizers.

RESEARCH ON. Forschungsarbeiten ueber den Waermedurchgang (Research on Heat Transfer), W. Nusselt. Forschung auf dem Gebeite des Ingenieurwesens, vol. 2, no. 11, Nov. 1931, pp. 408–413. Report on 35 treatises published in Forschungsarbeiten auf dem Gebiete des Ingenieurwesens: heat conduction and accumulation in solid bodies; heat transfer of gases; superheated steam and liquids; heat radiation; heat transfer in engines.

TUBES. Heat Transmission Rates Round Tube in Transverse Current of Fluid, J. Small. Engineering, vol. 132, no. 3434, Nov. 6, 1931, pp. 569–570, 5 figs. Investigation carried out in Engineering Laboratories of University of Glasgow, deals only with special case of isolated tube placed in uniform air current.

HIGH-SPEED STEEL

TEMPERATURE EFFECT. Anlassbestaendigkeit und Warmhaerte von Schnelldrehstahl (Temper and High-Temperature Hardness of High-Speed Steel), F. Rapatz and H. Kallen. Stahl und Eisen, vol. 51, no. 44, Oct. 29, 1931, pp. 1339–1340, 4 figs. Investigations of various alloy steels; influence of higher hardening temperature.

HYDRAULIC TURBINES

CAVITATION. Cavitation of Large Turbine Runners, A. S. Robertson. Hydro-Elec. Power Commission Ontario—Bul., vol. 18, no. 10, Oct. 1931, pp. 368–373, 4 figs. General outline, causes, and results of phenomena of cavitation or pitting; experiments with runners repaired by electric welding in Hydro-Electric Power Commission of Ontario.

DESIGN. Schnellaufende Turbomaschinen fuer Fluessigkeiten (High-Speed Turbines for Liquids), W. Hahn. V. D. I. Zeit., vol. 75, no. 42, Oct. 17, 1931, pp. 1293–1296, 17 figs. Solution of difficulties concurrent to high speed; determination of dimensions and conditions for different operating conditions; pressure distribution over blade; investigation of cavitation limits by model tests; corrosion problems.

HYDROELECTRIC POWER PLANTS

FRANCE. Aménagement de la Cére par la Société hydroélectrique de la Cére (Hydroelectric Development of the Cére, by "Société hydroélectrique de la Cére"), Herbert. Science et Industrie, vol. 15, no. 212, Sept. 1931, pp. 423–434, 12 figs. Description of Laval-de-Cére plant, utilizing gross head of 109 m and having capacity of 30,000 hp; features of headworks, power canal, concrete flume crossing stream on concrete-arch bridge, etc.; mechanical and electrical equipment of power plant.

I

IMPACT TESTING

NOTCHED-BAR. Der Stand der Kerbschlagprobenfrage in Deutschland (Status of Notched-Bar Impact Test in Germany), M. Moser. Kruppsche Monatshefte, vol. 12, Aug.–Sept. 1931, pp. 223–229, 9 figs. Advantages of notched-bar impact test; comparison of different tentative standards; dimensions of final specimens.

INDUSTRIAL LIGHTING

AUTOMATIC CONTROL. Automatic Control of Industrial Lighting, E. H. Vedder and S. G. Hibben. Mill and Factory Illustrated, vol. 9, no. 4, Oct. 1931, pp. 36–37, 5 figs. Survey of advantages of automatic control; circuit diagram of typical photo-cell automatic unit shows standard Mazda lamp used for pilot.

INDUSTRIAL MANAGEMENT

BUDGET CONTROL. Budgeting, C. M. Bigelow. Wood Working Industries, vol. 10, nos. 4 and 5, Oct. 1931, pp. 17–19 and 23, and Nov., pp. 25–28, 4 figs. Outline of importance, purpose, and operating features of budgeting; master budget, sales forecasting and relation to budgetary control plan; complexity of factors.

COST ACCOUNTING. Machine Tool Plant Keeps Separate Costs for Engineering Work, T. B. Frank. Iron Age, vol. 128, no. 24, Dec. 10, 1931, pp. 1475–1478, 6 figs. Estimate sheet used by Cincinnati Planer Co. on all development work, with columns showing items of estimated cost and actual cost.

Profitable Plans for Medium Sized Plant—II, C. F. Scribner. Wood Working Industries, vol. 10, no. 5, Nov. 1931, pp. 20–22, 1 fig. Devising cost plans that permit prompt use of facts for purpose of executive control and guidance.

PRODUCTION CONTROL. Arbeitsvorbereitung im Konstructionsbuero (Work Preparation and Designing), E. Eichwald. Maschinenbau, vol. 10, no. 14, 1931, July 16, 1931, pp. 461–466, 5 figs. Advantages of economical designing with particular regard to utilization of standard

(DIN); procedure of keeping records, setting up of specifications, and making those existing available to designer.

Kostengefaelle, Losgroesse und Normung (Cost, Lot Sizes, and Standardization), P. Reich. Maschinenbau, vol. 10, no. 17, Sept. 3, 1931, pp. 553–559, 14 figs. Increase in quantity production by application of standardization; calculations of possible economies; evaluation of new production methods by graphical extrapolation.

Die Wirtschaftsplanung in Industrie-Unternehmungen (Production Planning in Industrial Enterprises), R. Koch. Maschinenbau, vol. 10, nos. 14 and 15, July 16, 1931, pp. 467–470, and Aug. 6, pp. 492–495, 1 fig. Example of automobile plant illustrates planning of production including particularly cost calculation and ordering of materials.

[See also *Automobiles—Production Control.*]

INDUSTRIAL PLANTS

STANDARDIZATION. Organization of Standardization Work in Ingersoll-Rand Company, A. Huntress. ASA Bul., no. 66, Oct. 1931, pp. 23–25. Study of successful standardization programs results in elimination of unnecessary variations in products and plant procedures; part of discussion of paper "Fundamental Role of Standardization in Operations of Bell System," H. S. Osborne.

WINDOWLESS. "Controlled Conditions" Plant, H. E. Stitt. Iron and Steel Engr., vol. 8, no. 11, Nov. 1931, pp. 474–478. Operating efficiencies attained by layout and facilities of Simonds windowless plant at Fitchburg, Mass.; air conditioning, lighting, heating, sound control, materials-handling equipment; shortening workday hours and possibility of increasing number of shifts per day; overhead expense, interest, taxes, and insurance same for 24-hr day as for 8-hr day.

INTERNAL-COMBUSTION ENGINES

BEARINGS. Waelzlager fuer Kurbel-und Pleuellager (Ball and Roller Bearings for Crankshaft and Connecting-Rod Bearings), Rothweiler. Automobiltechnische Zeit., vol. 34, no. 32, Nov. 20, 1931, pp. 731–734, 9 figs. Advantages with regard to lubrication, particularly illumination of pressure systems; data on dimensioning and durability for different loads and speed.

CASTINGS. Produces Engines for Automotive, Marine and Industrial Purposes, E. Bremer. Foundry, vol. 59, no. 22, Nov. 15, 1931, pp. 31–34, 6 figs. Molding and casting methods of Buda Co., in making flywheels, flywheel housings, gear-case covers, heavy 6-cylinder motor blocks, and castings.

VALVES AND VALVE SEATS. Renewable Valve Seats Cut Maintenance Costs by Eliminating Necessity for Periodic Regrinding, P. M. Heldt. Automotive Industries, vol. 65, no. 21, Nov. 21, 1931, pp. 794–796, 2 figs. Design and tests of valve seats of composite construction being made of carbon steel and special heat-resisting alloys; Mack construction shows shrunk-in seats held by headed screws; in White heavy-duty engines seats are screwed into block and locked by set screws.

Valves and Valve Steels and Their Heat Treatment, E. F. Davis. Fuels and Furnaces, vol. 9, nos. 10 and 11, Oct. 1931, pp. 1135–1142 and Nov. pp. 1259–1264, 5 figs. Variations in steel analyses and physical properties from which choice may be made for steels used in valves; recent development of valve steels, methods of manufacturing valves, heat treatment, and properties imparted to valve steels by more important metallic elements; methods of manufacturing valves, heat treatment, and methods of testing.

VIBRATIONS. Théorie des oscillations de torsion des lignes d'arbres de moteurs à combustion interne (Torsional Oscillations of Internal-Combustion-Engine Shafting), J. Mancy. Bul. Technique du Bureau Veritas, vol. 13, no. 8, Aug. 1931, pp. 156–159. Calculation proposed uses single equivalent mass and equivalent system known as equivalent oscillator; by application of theory, torsional fatigue can be reduced, critical speeds avoided, and accurate damping arrangements developed.

[See also *Airplane Engines; Automobile Engines; Diesel Engines; Gasoline Engines; Oil Engines.*]

IRON AND STEEL

COLD WORKING. Ueber das Aufreissen von kaltgezogenem Rundeisen (Rupture of Cold Drawn Round Iron), W. Fahrenhorst and G. Sachs. Metallwirtschaft, vol. 10, no. 41, Oct. 9, 1931, pp. 783–788, 13 figs. Results of tests on bars made from Thomas ingot iron to determine causes of rupture; structure and chemical composition of rolled bars; investigation of strength; great influence of polishing is shown.

K

KINEMATICS

COMPOSITE LINK MOTIONS. Zusammengesetzte Gelenkgetriebe (Composite Link Motions), H. Blaise. V.D.I. Zeit., vol 75, no. 42, Oct. 17, 1931, pp. 1303–1309, 21 figs. Utilization of oscillating crank for oscillating and rotating drives; application to manufacture of safety pins; kinematics of double cranks.

L

LAPPING MACHINES

USE ON FLAT WORK. Machine Lapping Employed in Refrigerator Manufacture, R. A. Fiske. Iron Age, vol. 128, no. 21, Nov. 19, 1931, pp. 1283–1285, 3 figs. Utilization of lapping machines at Majestic Refrigerator plant of Grigsby-Grunow Co., Chicago; battery of 27 I-F lapping machines made by Norton Co., Worchester, Mass., for flat work.

LATHES

MANUFACTURE. Making VDF Standard Lathes. Machy. (Lond.), vol. 39, no. 994, Oct. 29, 1931, pp. 137–141, 12 figs. Quantity-production methods applied to manufacture of machine tools in shops of Gebrueder Boehringer, Goeppingen; lathes varying in height of centers from 6⅜ in. to 17¾ in.; diagram showing layout of Boehringer Works; data on tolerances, feed, and output.

LIQUIDS

ATOMIZATION. Zum Zerfall eines Fluessigkeitsstrahles (Disintegration of Liquid Jet), C. Weber. Zeit. fuer angewandte Mathematik und Mechanik, vol. 11, no. 2, Apr. 1931, pp. 136–154, 22 figs. Theoretical analysis of experiment by A. Haenlein, whose paper was previously indexed from Forschung auf dem Gebiete des Ingenieurwesens, Apr. 1931; effect of surface tension, air supply, etc.

LOCOMOTIVES

TESTING. Santa Fe Locomotive 5000 Tested. Ry. Age, vol. 91, no. 22, Nov. 28, 1931, pp. 829–832, 3 figs. Modern 2-10-4 type engine handles 15 per cent more tonnage in 9 per cent less time and with 17 per cent less unit fuel consumption; principal features of locomotive design; general performance of Locomotive 5000 in freight service test runs on Pecos division of Santa Fe; general characteristics and dimensions.

M

MACHINE DESIGN

CRANK-EFFORT ANALYSIS. Analytical Study of Crank Efforts in Reciprocating Engines, A. Kobayashi. Ryojun College Eng.—Memoirs vol. 4, no. 3, Aug. 1931, pp. 127–183, 24 figs. Analytical procedure adopted gives directly expressions for unbalanced forces and crank effort without neglecting speed fluctuation above mentioned; such expressions are indispensable for computing, for example, torsional vibration of flexible shaft, especially in case of multi-cylinder engines. (In English.)

NOTCHED SECTIONS. Zur Steigerung der Dauerfestigkeit gekerbter Konstruktionen (Increasing Fatigue Strength of Notched Members), A. Thum. V.D.I. Zeit., vol. 75, no. 43, Oct. 24, 1931, pp. 1328–1330, 8 figs. Research by Oschatz, and others showing how internal stresses may be built up to protect unavoidable notched sections against fatigue failure, which generally starts near surface; inducing plastic deformation at surface counteracting fatigue fracture.

UNUSUAL EXPERIENCES IN. Unusual Experiences in Designing Machine Elements, D. L. Lindquist. Product Eng., vol. 2, no. 10, Oct. 1931, pp. 441–445, 5 figs. Review of particular problems encountered in designing shafts, bearings, brakes, couplings, and other parts, and manner in which difficulties were overcome.

MACHINE TOOLS

IRREGULAR SURFACES. Maschine à usiner les surfaces gauches (Machine Tools for Machining Irregular Surfaces). Génie Civil, vol. 99, no. 15, Oct. 10, 1931, pp. 369–371, 3 figs. Design and operation of machine tools, particularly suited for machining wheels of hydraulic turbines; equipped with Hele-Shaw hydraulic drive and built by Société des Ateliers des Charmilles, Geneva.

REPLACEMENT. Continuous Replacement at 10 Per Cent Per Year, H. K. Spencer. Am. Mach., vol. 75, no. 22, Nov. 26, 1931, pp. 798–802, 6 figs. Replacement policy of Blanchard Machine Co., Cambridge, Mass., manufacturers of surface grinding machines; list of machine tools as of July 1, 1931, age of equipment averages but 7.7 years.

Replacement by Formula, R. F. Runge. Am. Mach., vol. 75, no. 21, Nov. 19, 1931, pp. 762–766, 4 figs. Replacement policy of SKF Industries, Inc., has more than doubled its production per square foot of floor space and at same time improved quality; application of equipment replacement formula.

Replacement Policy that Shares Responsibility, R. C. Blanchard. Am. Mach., vol. 75, no. 20, Nov. 12, 1931, pp. 728–740, 16 figs. How Norton Company, Machine Division increased production capacity 15 per cent, reduced production floor space 20 per cent, improved quality and cut average of its equipment to 8.9 years.

RIGIDITY IN. Der Starrheitsgrad von Werkzeugmaschinen (Rigidity of Machine Tools)-C. Krug. Maschinenbau, vol. 10, no. 15, Aug. 6, 1931, pp. 505–506. Discussion of article by Reichel, previously indexed from Apr. 16, 1931, issue of same journal; establishment of unit of rigidity for machine tools; critical application to work of Reichel.

MACHINERY

PAINTING. Will Colors on Machines Pay, H. Chase. Am. Mach., vol. 75, no. 22, Nov. 26, 1931, pp. 807–809, 2 figs. Introducing yellows and blues and greens into metal-working shop produces profitable results.

PHOTOELECTRIC-CELL CONTROL. Electronic Control of Machinery, R. F. Yates. Iron Age, vol. 128, no. 21, Nov. 19, 1931, pp. 1299–1300 and 1349, 1 fig. Production gages, in which Movement of anvils is amplified electrically by vacuum tube; grid-glow tube used in new stroboscope.

MACHINING METHODS

BRIDGE-CABLE SADDLES. Machining Saddle Castings for Hudson River Bridge Cables, S. G. Koon. Iron Age, vol. 128, no. 20, Nov. 12, 1931, pp. 1230–1233 and 1281, 8 figs. Finishing grooves for successive strands of cable to definite arc of circle of 30 ft radius within tolerances measured in thousandths of inch by Midvale Co., through use of special equipment.

MALLEABLE-IRON CASTINGS

PROPERTIES. Mechanical Properties of Malleable Iron on Various Sized Test-Bars, A. L. Norbury. Foundry Trade Jl., vol. 45, no. 789, Oct. 1, 1931, pp. 205–208, 24 figs. Results of mechanical tests; tensile strength; properties of black-heart and white-heart malleable.

MATERIALS TESTING

METHODS. Stoffpruefund (Testing of Materials), E. Lehr. V. D. I. Zeit., vol. 75, no. 46, Nov. 14, 1931, pp. 1401–1409, 12 figs. Survey of present-day knowledge of properties of materials, largely based on papers read at Zurich Conference of new International Society for Testing Materials; testing of metals; materials at high temperatures; notched-bar tests; fatigue; properties of inorganic and organic materials; calibration of testing machines; testing of textures and structures, etc.

METAL CUTTING

CUTTING SPEEDS. Die Schnittgeschwindigkeit beim Zerspanungsvorgang (Cutting Speed in Machining Process), W. Leyensetter. Werkzeugmaschine, vol. 35, nos. 18 and 19, Sept. 30, 1931, pp. 363–367 and Oct. 15, pp. 392–395, 17 figs. Relation between feed and speed, interpretation of principal research work with particular regard to tests of D. Smith and Wallichs; formulas for cutting speed.

EXPERIMENTS ON. Experiments on Cutting, S. Doi. Ryojun College Eng.—Memoirs, vol. 4, no. 4—A, Aug. 1931, pp. 243–255, 49 figs. partly on supp. plate. New method for measuring exactly both vibration of tool and cutting force which varies rapidly; by employing this method, experiments on cutting force and vibration of lathe tool were carried out. (In English.)

METALS

EXTRUSION. Extrusion Press in Working of Non-Ferrous Metals, L. G. Mitchell and H. Stewardson. Chem. Eng. and Min. Rev., vol. 23, no. 276, Sept. 1931, pp. 460–464, 3 figs. Features of 1000-ton hydraulically operated extrusion press; operating procedure; finishing; lead, tin, zinc, copper, and aluminum, and certain copper-zinc, copper-aluminum, and light aluminum alloys are suitable for extrusion; defects in extruded rods; flow of metal; application of extrusion press to steel. Before Melbourne Univ. Met. Soc.

PRESTRESSING. Materialverfestigung durch Vorspannung (Strengthening of Materials by Prestressing), E. Kreissig. Glasers Annalen, vol. 109, nos. 9 and 10, Nov. 1, 1931, pp. 77–80 and Nov. 15, pp. 85–88, 3 figs. Development of formula for stressing of materials; examples illustrate effect of strengthening by prestressing.

WEAR RESISTANCE. How Carbon Content and Heat Treatment Can Affect Wear Resistance, S. J. Rosenberg. Iron Age, vol. 128, no. 22, Nov. 26, 1931, pp. 1366–1367, 2 figs. Wear resistance of steels when subjected to two types of wear produced by Brinell sand-abrasion testing machine and Amsler wear-testing machine; wear caused by sliding abrasive action of sand under relatively light pressure, and wear under combined sliding and rolling friction under heavy pressures or metal-to-metal wear.

MOTOR TRUCKS

ENGINES—VAPORIZERS FOR. Paragon Vaporizer Is Designed for Heavy-Duty Engines. Automotive Industries, vol. 65, no. 22, Nov. 28, 1931, pp. 842–843, 3 figs. Operating principles and test results obtained with vaporizer for heavy fuels manufactured by Paragon Vaporizer Corp., Chicago.

FRANCE. Les poids Lourds en 1931 (Heavy Weights in 1931), E. Marcotte. Revue Industrielle, vol. 61, no. 2268, Nov. 1931, pp. 613–619, 14 figs. New features of representative makes; Sovel electric truck with storage battery; Michelin rail-motor cars with pneumatic tires; motor-truck and motor-bus chassis by Renault, Panhard et Levassor, Berliet.

RATING. Truck Rating Formulas, M. L. Pulcher. Soc. Automotive Engrs.—Jl., vol. 29, no. 4, Oct. 1931, pp. 336–338, 1 fig. Assuming direct relationship between weight of truck and its carrying capacity, author proposes formula be developed in which allowable gross weight of carrying capacity of truck should be product of weight of fully equipped chassis multiplied by constant.

N

NITRIDATION

SELECTIVE AND LOCALIZED. Selective and Localized Nitriding, W. J. Merten. Fuels and Furnaces, vol. 9, nos. 10 and 11, Oct. 1931, pp. 1145–1148 and Nov., pp., 1253–1256, 3 figs. Gaseous reactions of nitriding process, behavior of decomposition products and subsequent chemical attack; influencing intensity and mode of physico-chemical reactions of nitrogen and nitride-forming elements of alloy at temperature of process; importance of selective nitriding methods of conducting process.

NOZZLES

NEW FORMS—TESTS OF. Versuche mit neuen Formen von Durchflussduesen (Tests With New Forms of Nozzles), H. Richter. Forschung auf dem Gebeite des Ingenieurwesens, vol. 2, no. 11, Nov. 1931, pp. 387–394, 14 figs. Based on results of calculations, rules for design of nozzles are given, according to which discharge coefficient, from given Reynolds number on, is invariable; three different designs of nozzles are developed according to these concepts.

O

OIL ENGINES

HIGH SPEED. High-Speed Heavy-Oil Engines and Turbines. Engineering, vol. 132, no. 3434, Nov. 6, 1931, pp. 597–598, 3 figs. Review of papers in this subject presented at International Congress for General Mechanics at Liége in 1930, contained in Proceedings of Congress.

OPEN-HEARTH FURNACES

FUELS FOR. Successful Open-Hearth Operation With Coke Oven Gas, A. J. Ebner. Blast Furnace and Steel Plant, vol. 19, no. 11, Nov. 1931, pp. 1459–1461, 3 figs. Layout and operation at Hoesch open-hearth shop comprising total of nine factories, five of which are 30-ton units, three of 100-ton, and one of 150-ton capacity; gas consumption based on actual time of heats from tap to tap on all nine furnaces averages 8390 cu ft per ton, or heat input of about 4,400,000 Btu per ton of steel.

OXYACETYLENE CUTTING

HEAVY PLATE. Machine Gas-Cutting Heavy Plate, L. M. Curtiss. Steel, vol. 89, no. 21, Nov. 16, 1931, pp. 31–33 and 38, 8 figs. Effect of gas cutting on physical and chemical characteristics of steel plate; chart showing relation between affected zone at edge of plate and thickness of plate; investigation by Lukens Steel Co., Coatesville, Pa. Before Int. Acetylene Assn.

P

PIPE LINES

STRESSES. Note sur le calcul des sollicitations d'une tuyauterie parcourue par un fluide incompressible, etc. (Calculation of Stresses in Pipe Line Traversed by Incompressible Fluid in Permanent or Variable Flow), A. J. Jadot. Revue Universelle des Mines, vol. 6, nos. 4, 5, 6, 8, and 9, Aug. 15, 1931, pp. 92–98, Sept. 1, pp. 117–123, Sept. 15, pp. 154–160, Oct. 15, pp. 235–241, and Nov. 1, pp. 286–292, 27 figs. Investigation shows that general formulas can be safely applied in most cases.

PLASTICITY

SLIP PHENOMENON. Phenomenon of Slip in Plastic Materials, A. Nadai. Am. Soc. Testing Matls.—Proc., vol. 31, pt. II, 1931, 36 pp., 40 figs. Models of various states of matter; surfaces of slip; ideal loose material; Schlieren method for observing flow layers in plastic materials; flow layers produced under various states of stress; slip lines in plane fields of stress in plastic materials; surfaces of slip in geology; use of new optical bench designed by author for study of formation of plastic slip layers in test specimens.

POWER PLANTS

GRAPHIC MODELS. Contour Map Facilitates System Load Study, W. H. Prescholdt. Elec. World, vol. 98, no. 17, Oct. 24, 1931, p. 737, 1 fig. Characteristics of system load are frequently represented, for convenience in studying them, by three dimensional graphs; same information, in form more convenient to handle, easier to study and from which copies may readily be made, can be presented in two dimensions as contour map of relief graph.

Die Auswertung von Belastungsbebirgen fuer die Untersuchung von Speicherungsfragen (Use of Load Mountains for Study of Power Storage Problems), L. Musil. Elektrotechnische Zeit., vol. 52, no. 46, Nov. 12, 1931, p. 1416, 2 figs. Utilization made possible by drawing of lines of equal daily totals.

PRESSES

HYDRAULIC FORGING. Les presses hydrauliques pour forger les gros lingots d' acier (Hydraulic Presses for Forging of Large Steel Ingots), J. Seigle. Technique Moderne, vol. 23, no. 18, Sept. 15, 1931, pp. 613–620, 25 figs. Principles of design, with particular regard to forging; characteristics of representative makes including Tannet, Breuer-Schumacher, Haniel et Lueg.

SCREW. A Free-Wheeling Screw Press, F. R. Daniels. Machy. (N. Y.), vol. 38, no. 2, Oct. 1931, pp. 130–131, 3 figs. Quality of product of standard screw press is improved by applying free-wheeling power transmission; plan view, illustrating crank connection and action of screw when driven through roll friction clutch.

PRESSURE GAGES

HIGH-PRESSURE. High-Pressure Technic, F. G. Keyes. Indus. and Eng. Chem., vol. 23, no. 12, Dec. 1931, pp. 1375–1379, 6 figs. Apparatus for measurement of pressures has reached stage where precision of 1 part per 10,000 to 600 atm. is not difficult; device suited for this precise measurement is piston, or so-called dead-weight gage; calibration of piston gages; hitherto unpublished characteristics of gages described.

PRESSURE VESSELS

WELDING. Address to American Boiler Manufacturers Association, C. A. Adams. Combustion, vol. 3, no. 4, Oct. 1931, pp. 16–21 and 24. Various methods of welding and respective advantages and limitations; particular stress on importance of X-ray test method prescribed in recent A.S.M.E. Code for Welded Boiler Drums; practical discussion of welding equipment and operations. Before Am. Boiler Mfrs. Assn.

Die Anwendung der Lichtobogenschweissung beim Bau von Hochdruckbehaeltern (Application of Arc Welding in Construction of High-Pressure Vessels), E. Joellenbeck and C. Massmann. Elektroschweissung, vol. 2, no. 9, Sept. 1931, pp. 165–169, 10 figs. Tests at Tegal plant of A. Borsig Co. in Berlin with reference to strength and properties of welds, in order to determine their value for construction purposes; test results in tables.

PUMPING PLANTS

GREAT BRITAIN. Aubrey Street Pumping Station, J. R. Davidson. Water and Water Eng., vol. 33, no. 396, Nov. 20, 1931, pp. 563–571, 8 figs. History of plant since 1857 and description of new installation consisting of three separate electrically-driven centrifugal pumps, automatically controlled from high-level tank; each of three pumps is capable of delivering 2500 gpm against total head of 110 ft; details of high-tension control board and transformers.

New Pumping Station at Saints Hill, W. H. Maxwell. Water and Water Eng., vol. 33, no. 396, Nov. 20, 1931, pp. 578–586, 5 figs. Description of well pumping plant having capacity of 700,000 gal per day; plant is equipped with turbine-type centrifugal 16 in. diam., four-stage, driven electrically; details of Venturi meter and recorder, water-level indicators, concrete clear water tanks, air compressors, and motors; mechanical filters.

PUMPS

CONSTANT-DISPLACEMENT. Constant-Displacement Pumps for Machine Actuation. Product Eng., vol. 2, nos. 9 and 10, Sept. 1931, pp. 410–414 and Oct., pp. 459–461, 21 figs. Design, construction and operating characteristics of gear pumps; performance tests of various gear pumps; recent development of vane and centrifugal pumps has widened application of field of hydraulic control; characteristics and performance data of these types.

VACUUM. Neuartige Pumpe fuer Wasserdampf niedriger Spannung (New Types of Pumps for Low-Pressure Water Vapor), P. Schlumbohm. Chemische Fabrik, vol. 4, no. 44, Nov. 4, 1931, pp. 429–430, 1 fig. Apparatus with which large quantities of water can be evaporated at very low temperatures; in addition to other applications when used with evaporator it is cheap and efficient refrigerating machine; consists of continuous absorber combined with high-vacuum pump.

R

REDUCTION GEARS

VARIABLE-SPEED. Motovariatore Variable-Speed Gear. Engineering, vol. 132, no. 3434, Nov. 6, 1931, pp. 596–597, 3 figs. Ingenious form of gear constructed by V. Fachini, Milan, used, among other applications, for operating gun training and elevating gear on warships of Italian type, giving infinitely variable reduction ratio over certain range of speeds in both directions of rotation.

REFRIGERANTS

CARBON DIOXIDE. Ueber die Herstellung von fester Kohlensaeure (Manufacture of Solid Carbon Dioxide), J. Kuprianoff. Zeit. fuer die gesamte Kaelte-Industrie—Beihefte, series 2, no. 4, 1931, 59 pp. Properties of solid carbon dioxide as refrigerant; manufacturing processes; thermodynamic analysis of different processes; results of author's tests. Bibliography and list of patents.

HEAT PROPERTIES. Die thermischen Eigenschaften einiger Stoffe von hohem Molekulargewicht, etc. (Heat Properties of Some Materials of High Molecular Weight with Special Regard to Their Use in Refrigerating Machines With Turbo-Compressors), A. W. Hsia. Zeit. fuer die Gesamte Kaelte-Industrie, vol. 38, nos. 10 and 11, Oct. 1931, pp. 150–155, and Nov., pp. 167–169, 5 figs. Oct.: Investigation of methyl bromide; vapor pressure and specific weight. Nov.: Dichloro-ethylene.

RIVETED JOINTS

TESTING. Riveted Tension Members, T. R. Loudon. Eng. Jl., vol. 14, no. 11, Nov. 1931,

pp. 554–557, 7 figs. Research by photoelastic method to determine reasonable deduction formula for use with riveted tension members; stress lines were ascertained both for tension plates with rivet holes in them and for tension plates actually riveted together; tests on steel plates; deduction formula is proposed taking account of stagger and gage distance.

ROLLING-MILL PRACTICE

SPREAD IN ROLLING. Die Klaerung der Breitungsfrage beim Walzen mit Hilfe der Spannungsflaechenhypothese (Solution of Spreading Problem in Rolling With Aid of Surface Tension Hypothesis), W. Tafel and W. Knoll. Metallwritschaft, vol. 10, no. 42, Oct. 16, 1931, pp. 799–806, 12 figs. Explanation of hypothesis derivation of formula for spread; influence of roll diameter and width of bar on spread; calculation of spread of non-ferrous metals.

ROLLING MILLS

BILLET AND ROD MILLS. New Billet and Rod Mills at Donora Steel Works. Blast Furnace and Steel Plant, vol. 19, no. 11, Nov. 1931, pp. 1455–1458, 9 figs. Improvements and additions to Donora plants of American Steel & Wire Co.; continuous billet mill; annual capacity of two continuous rod mills is about 200,000 tons of rods, ranging in size from no. 5 to $^{9}/_{16}$ in., inclusive.

S

SAND, FOUNDRY

PROPERTIES. Factors Which Influence Surface Quality of Gray Iron Castings, W. G. Reichert and D. Woolley. Am. Foundrymen's Assn.—Trans. and Bul., vol. 2, no. 8, Aug. 1931, pp. 205–231, and (discussion) 231–234, 17 figs. Authors conducted series of investigations to determine influence of varying sand conditions on face of casting; conclusions were that grain size and moisture content are main factors which influence surface quality.

SCREW MACHINES

OPERATION OF. Das Arbeiten auf Mehrspindelautomaten (Operation of Screw Machines), P. Kelle. Werkzeugmaschine, vol. 35, nos. 13 and 14, July 15, 1931, pp. 261–264 and July 31, pp. 286–289, 21 figs. Economy in screw-machine operation derived from proper division of operations; gaging methods.

SCREW THREADS

STANDARDIZATION. Gewindetoleranzen (Thread Tolerances), N. N. Sawin. Maschinenbau, vol. 10, no. 18, Sept. 17, 1931, pp. 588–593, 7 figs. Critical interpretation of German thread standard based on experimental at Skodawerke, Pilsen; suggestion for international thread standardization; screw-thread gages.

THREAD-CUTTING MACHINES. McLeod-Richards Thread Milling Machine. Engineer, vol. 152, no. 3955, Oct. 30, 1931, pp. 459–462, 8 figs. Richards system of thread milling; difficulty caused by facets; McLeod's solution of problem embodied in machine produced at Company's works to order of Stewarts and Lloyds, for thread, milling tubes and sockets from 4 to 11 in. diam. as used in oil fields.

SEAPLANES

CATAPULTS FOR. Die Flugzeugschleuder der Deutsche Werke Kiel Aktiengesellschaft (Airplane Catapults of Deutsche Werke Kiel A. G.), O. Richter. Schiffbau, vol. 32, no. 19, Oct. 1, 1931, pp. 423–426, 5 figs. Catapult works on principle of reversed tackle, and is different from usual type in that moving tackle is rigidly connected to gliding rail, and therefore rail is moved along with tackle during launching.

Launching by Catapult, L. J. Wackett. Flight, vol. 23, no. 44, Oct. 30, 1931, pp. 1086f–1086h, 2 figs. Operating principles of compressed-air and powder-propelled catapult; calculation relating to dynamics of launching; length of run and acceleration.

SHAFTS AND SHAFTING

GROUP DRIVE. Power Losses in Group Drives, R. W. Drake. Maintenance Eng., vol. 89, no. 10, Oct. 1931, pp. 484–486, 3 figs. Consideration of following power losses: friction in lineshaft hanger bearings, friction in countershaft hanger bearings, pulley windage, belt windage, belt slip, and creep and miscellaneous losses; curves illustrating losses in line shaft hanger bearings under various loads.

SHAPERS, METAL-WORKING

ELECTRIC. Electrically-Operated Circular Shaping Machine. Engineering, vol. 132, no. 3426, Nov. 20, 1931, p. 638, 1 fig. Machine by Greenwood and Batley, is designed to cut through internal circumferential ridge left in center of long tubes bored from each end; operation involves cutting reciprocating action and rotary indexing action; headstock contains main driving motor and gear-changing mechanism.

SHEET-METAL WORKING

STAMPING. Schiebertafel fuer die Rohmengen- und Rohgewichts bestimmung von Stanzteilen (Slide Rule for Determination of Quantity and Weight of Raw Materials for Stamped Parts), H. Schmid. Maschinenbau, vol. 10, no. 16, Aug. 20, 1931, pp. 529–531, 14 figs. Graphic methods illustrated by example; results, including waste, are obtained without lengthy calculations by using finished dimensions in adjusting slide.

SMOKE ABATEMENT

CHIMNEY GASES. Dust in Chimney Gases. World Power, vol. 16, no. 95, Nov. 1931, pp. 384 and 386, 3 figs. Economic and social consequences of atmospheric pollution are widely recognized; general agreement on need for rigorous application of smoke abatement devices wherever possible.

STANDARDIZATION

PREFERRED-NUMBER. Standardization by Preferred Numbers, R. E. Hellmund and J. I. Hommel. Am. Mach., vol. 75, no. 19, Nov. 5, 1931, pp. 697–700, 2 figs. Preferred numbers recommended by American Standards Association; optional system of fractional preferred numbers, with same percentage steps as decimal series, namely, 60 per cent, 25 per cent, 12 per cent, and 6 per cent, but with decimals changed to fractions developed by Westinghouse Electric and Manufacturing Company.

STEAM

CALORIMETRY. Steam Research in Europe and in America, M. Jakob. Engineering, vol. 132, no. 3432, Oct. 23, 1931, pp. 518–521, 9 figs. Calorimetric measurements; direct measurements of latent heat of steam at high pressures; energy of superheat. 2nd lecture before Univ. London.

RESEARCH. Steam Research in Europe and in America—III, M. Jakob. Engineering, vol. 132, no. 3436, Nov. 20, 1931, pp. 651–653. Fundamental thermodynamical properties of water and steam.

STEAM CONDENSERS

SURFACE. Surface Condenser Principles. Blast Furnace and Steel Plant, vol. 19, no. 11, Nov. 1931, pp. 1475–1478, 3 figs. Theoretical formula upon which condenser design is based; effect of temperature of circulating water on heat transfer; graphs illustrate variations of turbine water rates with different vacuums and loads; curves showing effect on heat transfer of various cleaning methods.

STEAM-ELECTRIC POWER PLANTS

CONTROL. Schaltplaene fuer Betriebskontroll-Messanlagen in Waermekraftwerken (Diagrams of Connection for Supervisory Control Measuring Installations in Steam Power Plants), P. E. Quintes. Elektrotechnische Zeit., vol. 52, no. 47, Nov. 19, 1931, pp. 1438–1442, 6 figs. Method of control and symbols recommended for use by manufacturers; temperature measuring and electric control equipment.

DESIGN. Developments in Power Station Design, S. L. Pearce. Engineering, vol. 132, no. 3439, Dec. 11, 1931, pp. 739–740. Progress during past 20 years; factors influencing design and operation of power stations; present movement in direction of higher steam pressures and temperatures, reheating, regeneration, feed heating and binary-fluid cycles. Before Junior Instn. Engrs.

GREAT BRITAIN. Boiler Equipment at New Kirkstall Power Station. Eng. and Boiler House Rev., vol. 45, no. 3, Sept. 1931, pp. 148, 150, 152, 154, 156 and 158, 5 figs. Layout of boiler house and plant which supplies electricity to City of Leeds; design, construction, and operating characteristics of boiler equipment; coal-handling plant; coal preparation; ash- and dust-removal plant.

Clarence Dock. Elec. Rev., vol. 109, no. 2814, Oct. 30, 1931, pp. 655–657, 6 figs. Station is designed for ultimate generating-plant capacity of 400,000 kw; eight 50,000 kw turbo-alternator sets; seven running and one standby, and total steaming-plant capacity of 5,120,000 lb per hr (normal); boiler house at present contains four Babcock and Wilcox boilers, each with normal evaporation capacity of 160,000 lb per hr for 450 lb per sq in. and 750 F.

Clarence Dock Power Station of Liverpool Corporation. Engineering, vol. 132, no. 3436, Nov. 20, 1931, pp. 632–635, 6 figs. Details of switchgear and circuit breakers; breakers are operated by solenoids; supply of energy for driving station auxiliaries; 50-kva 0.4/50-kv testing transformer will be used for testing insulators and other equipment.

LINCOLN, NEB. Lincoln's New Generating Plant Bleeds Steam for District Heating and Process. Power, vol. 74, no. 25, Dec. 22, 1931, pp. 885–890, 10 figs. Economical 12,000-kw. plant housed in modern artistic building, built for $110 per kw.; economizers, air preheaters, and stage heating of feed water contribute to over-all boiler plant efficiency of 86 per cent; equipment design and operation.

ST. DENIS, FRANCE. St. Denis Heralds New Era in French Steam Practice, R. H. Andrews. Power, vol. 74, no. 26, Dec. 29, 1931, pp. 921–924, 4 figs. Design and construction of new high-pressure steam power plant being erected with steam at 925 lb. pressure and 880–930 deg. fahr.; water-cooled combustion chambers; features of generating units; condenser layout; dust prevention.

STAND-BY. Die Grossdieselmotoren im Dienste der Elektrizitaetswirtschaft (High-Powered Diesel Engines in Electric Power Practice), M. Gercke. Mitteilungen aus den Forschungsanstalten, no. 5, May 1931, pp. 101–119, 10 figs. Use and advantage of engines as peak load standby is discussed on basis of operating data and tables; economic aspects.

STEAM ENGINEERING

GREAT BRITAIN. Future of Steam Engineering in Great Britain, D. Brownlie. Steam Engr., vol. 1, nos. 1 and 2, Oct. and Nov. 1931, pp. 5–7, 10, and 55–60, 8 figs. Oct.: Much increased use of electricity and efficient utilization of exhaust steam outstanding; reference made to district steam heating operation in United States. Nov.: Utilization of low-grade fuels, blast-furnace, and coke-oven gas, and household refuse, combined carbonization, and combustion, and coordination of fuel and power production and supply.

STEAM ENGINES

HIGH-SPEED. Novel Design of High-Speed Steam Engine. Engineer, vol. 152, no. 395, Nov. 13, 1931, p. 525, 2 figs. In engine produced by Drysdale & Co., two valves are incorporated for control of one cylinder and valve chests and valve rods are placed in front of instead of in line with cylinder; it is used for driving circulating pumps, dynamos, and other auxiliary machinery.

STEAM POWER PLANTS

AUTOMOBILE PLANTS. Ford Motor Company's 1200-Pound Steam-Plant Installation, A. R. Smith and H. B. Hanson. Am. Soc. Mech. Engrs.—Advance Paper, no. 44, for mtg., Nov 30–Dec. 4, 1931, 7 pp. General features of 110,000-kw, 1200-lb pressure, turbine-generator installation in Ford Plant at River Rouge; replaces and occupies no more space than equipment which had only one-eighth capacity; change has been made without interruption of service, and with little or no exterior evidence of such complete rehabilitation.

HEATING AND POWER. Die Aufteilung der Kosten bei Heizkraftwerken (Allocation of Costs in Combined Heating and Power Plants), G. Poelitz. Waerme, vol. 54, no. 42, Oct. 17, 1931, pp. 773–776, 2 figs. Method of allocating common operating costs of combined plant to central-heating and power-plant sections individually; fuel distribution; wages; maintenance and repair.

HIGH-PRESSURE. Darstellung der Vorgaenge in einer Hoechstaruckdampfmaschine mit Hilfe des TS-Diagrammes (Determination of Phenomena in Super-Pressure Steam Engine With Aid of TS-Diagram), Schmolke. Waerme, vol. 54, no. 45, Nov. 7, 1931, pp. 836–837, 1 fig. Example given shows how processes occurring in Benson boiler and two-stage steam turbine can be represented in TS diagram.

Betriebserfahrungen an der Hochdruckanlage des Gilbert-Kraftwerks (Experiences With Gilbert High-Pressure Plant), H. J. Vetlesen. Archiv fuer Waermewirtschaft, vol. 12, no. 12, Dec. 1931, pp. 349–352, 5 figs. Account of 1 year's experience at plant on Delaware River, formerly called Holland plant; data covering steam turbines, condensers, pipe lines, boilers, superheaters, economizers, feedwater pumps, etc.; special features.

STEAM TURBINES

DESIGN. De nyeste Fremskridt i Damptur-

binebygningen og dens nuvaerende Standpunkt (Latest Progress in Construction of Steam Turbines), K. Frey. Ingenioren, vol. 40, no. 38, Sept. 19, 1931, pp. 457–466, 17 figs. Progress in overcoming difficulties with installations operating at steam temperatures up to 500 deg. cent. and pressures of 200 atm.; selection of suitable steel; thermodynamic aspects.

OPERATION. Turbine Expansion Lines of Actual Machines. Power Plant Eng., vol. 35, no. 23, Dec. 1, 1931, pp. 1141–1144, 2 figs. Typical industrial and central station data serves as preliminary studies; expansion lines of several well-known industrial and central station turbines; pressures and temperatures.

VIBRATIONS. Experimental Investigation of Vibrations in Turbine Wheels and Blades, B. Pochobradsky, L. B. W. Jolley and J. S. Thompson. Engineering, vol. 132, no. 3433, Oct. 30, 1931, pp. 541–543, 13 figs. partly on supp. plates. Factors which enter into vibration are: vibration of complete wheel as one system and vibration of individual blades, or groups of blades, either axially or tangentially; effects of vibration; details of vibration laboratory at Fraser and Chalmers' Engineering Works; measuring apparatus.

STEEL

ABRASION. Study of Abrasion, S. Saito. Tohoku Imperial Univ.—Science Reports vol. 20, no. 4, Oct. 1931, pp. 560–573, 7 figs. Author has measured abrasion of steel using Amsler universal wear-testing machine, by which amount of abrasion due to combined sliding and rolling action may be known; powder remaining between abrasing pieces increases amount of wear; amount of wear between abrasing pieces differs according to their relative revolutions and hardness.

ANALYSIS. Workshop Spectroscope for Steel Examination. Engineering, vol. 132, no. 3439, Dec. 11, 1931, pp. 746–748, 5 figs. Instrument, known as Spekker Steeloscope, being made by A. Hilger, Ltd., consists of tripod stand on which is mounted metal box containing prisms, to which are attached two tubes, one carrying slit and the other the eye-piece.

CHROMIUM—MOLYBDENUM. See *Chromium—Molybdenum Steel.*

HARDENING. Contribution à l'étude du revenu des aciers trempés (Study of Tempering of Hardened Steels), P. Chevenard and A. Portevin. Revue de Métallurgie, vol. 28, no. 10, Oct. 1931, pp. 546–556, 31 figs. Tempering of austenite-martensite mixtures; hyper-eutectoid steel; mechanism of tempering.

HEAT TREATMENT—QUENCHING. Effets de la trempe à l'eau sur les aciers doux et extra-doux (Effects of Quenching on Mild and Extra-Mild Steels), J. Seigle. Revue de l'Industrie Minerale, no. 260, Oct. 15, 1931, pp. 383–394, 20 figs. Results of test; effect of quenching on tensile strength is greater than generally assumed; in certain temperature conditions and especially after subsequent aging, great sensitivity to impact develops, which, however is eliminated by tempering at 225 C.

HIGH-SPEED. See *High-Speed Steel.*

MACHINABILITY. Die Bewertung der Oberflaechenguete bei Zerspanungsversuchen (Evaluation of Surface Quality in Cutting Tests), K. Schimz. Stahl und Eisen, vol. 51, no. 46, Nov. 12, 1931, pp. 1402–1403, 2 figs. Results of tests show that surface quality improves with increasing cutting speed.

MICROSCOPIC EXAMINATION. Practical Application of the Microscope in Railway Service, H. Williams. Eng. Jl., vol. 14, no. 11, Nov. 1931, pp. 558–563, 15 figs. Microscopic examination of material involved in fracture of machine and structural parts found of very great value; illustrations of typical failures, principally in locomotive work; occurrence of failure from fatigue cracks.

RESEARCH. Research Laboratories of English Steel Corporation, Limited, Sheffield. Engineering, vol. 132, no. 3437, Nov. 27, 1931, pp. 683–684, 2 figs. Metallurgical and research department is divided into four main sections, respectively, dealing with chemical analysis, work observation, metallography, and research.

SCALE REMOVAL. Complete Descaling Before Grinding, F. R. Dedrick. Am. Mach., vol. 75, no. 22, Nov. 26, 1931, pp. 814–815, 3 figs. Grinding economies and savings resulting from adoption of Bullard-Dunn process; scale causes grinding wheels to load and thus impairs grinding.

TEMPERATURE EFFECT. Overheating and Burning of Mild Steel, E. Pohl, E. Krieger, and F. Sauerwald. Metallurgist (Supp. to Engineer), Oct. 30, 1931, pp. 148–149, 2 figs. Review of paper previously indexed from Stahl und Eisen, Mar. 12, 1931; authors take as measure of "overheating," size of ferrite grain developed in steel; measure of "burning" is obtained by observing depth to which oxide films can be seen under microscope to have penetrated into mass of steel from surface.

TESTING. Einfluss der Verformungsgeschwindigkeit auf den Formaenderungswiderstand (Effects of Speed of Deformation on Resistance to Deformation), W. Tafel and E. Viehweger. V.D.I. Zeit., vol. 75, no. 49, Dec. 5, 1931, pp. 1479–1483, 11 figs. Results of static upsetting tests with iron and lead under press and dynamic upsetting tests on anvil for determining numerical relations for high speed; new tests recommended for rivet steel; data on upsetting temperatures and number of blows; experiments at Technical University, Breslau.

STOKERS

OPERATION. Operating Characteristics of Overfeed Stokers. Power, vol. 74, no. 24, Dec. 15, 1931, pp. 858–860, 8 figs. Design and operating characteristics of several new types of overfeed stokers; refinements made to existing types; tables of overfeed stokers for heating, industrial and power boilers.

UNDERFEED. Underfeed Stokers for Heating, Industrial and Power Boilers. Power, vol. 74, no. 25, Dec. 22, 1931, pp. 898–902, 13 figs. Design, construction, and operating characteristics of underfeed stokers of single-, double-, and multi-retort types; embody screw and ram feed units in sizes for heating and power boilers of 150 sq ft of heating surface up.

STRESSES

INITIAL. Selbstspannungen elastischer Gebilde (Initial Stresses in Elastic Structures), P. Nemenyi. Zeit. fuer Angewandte Mathematik und Mechanik, vol. 11, no. 1, Feb. 1931, pp. 59–70, 1 fig. Review of theory on subject with special reference to Volterra, Weingarten and Somigliana distortions; general type of secondary local stresses due to manufacturing processes; temperature stresses.

CONFORMAL REPRESENTATION. Konforme Abbildung ebener Spannungszustaende (Conformal Representation of Plane Stress Conditions), L. Foeppl. Zeit. fuer Angewandte Mathematik und Mechanik, vol. 11, no. 2, Apr. 1931, pp. 81–92, 1 fig. Theoretical mathematical discussion leading to unification of Airy's stress function with Gauss' method of complex integration.

T

TEMPERATURE CONTROL

APPARATUS FOR. High-Temperature Control: Photoelectric-Tube Pyrometry, L. R. Koller. Indus. and Eng. Chem., vol. 23, no. 12, Dec. 1931, pp. 1379–1381, 4 figs. Work done in Research Laboratory, General Electric Co., on photoelectric-tube apparatus, by means of which it is possible to control temperature of industrial furnaces; method can be applied to temperatures of from 1000 C upward.

New Tools for High-Temperature Research, R. B. Sosman. Indus. and Eng. Chem., vol. 23, no. 12, Dec. 1931, pp. 1369–1374, 1 fig. Definition of high temperature; discussion centers around what seems weakest point in most high-temperature work; namely, failure to assure uniformity of temperature; methods and apparatus for measurement of high temperatures.

TEXTILE MILLS

WATER TREATMENT. Large Water-Softening Plant at Newton-Willows. Engineer, vol. 152, no. 3955, Oct. 30, 1931, pp. 471–472, 6 figs. Plant designed by T. Roland Wollaston, installed at calico printing and finishing works of J. F. and E. Caulfield, Lancashire; softener is designed to deal with 36,000 gal. of stream water per hour.

TOOLS, PORTABLE

ELECTRIC. Proper Maintenance Insures Portable Tool Efficiency, B. Y. Bandy. Mill and Factory Illustrated, vol. 9, no. 4, Oct. 1931, pp. 30–31 and 58, 7 figs. Practical discussion of proper operation and maintenance of electric portable tools.

TRACTORS

DIESEL. Catepillar Diesel Sixty Tractor, C. G. A. Rosen. Motive Power, vol. 2, no. 10, Oct. 1931, pp. 18–20, 4 figs. History of Diesel development by Catepillar Tractor Company dates back six or seven years, definite program of Diesel-engine investigation having been instigated about four years ago; outstanding feature of Diesel-engine design is removal of all field adjustments from fuel-injection apparatus equipment having been adjusted, regulated and timed at factory; spare fuel injection apparatus; engine specifications.

TURBO-BLOWERS

DESIGN. Entwurf und Ausfuehrung von Turbogeblaesen fuer Huettenwerke (Design and Construction of Turbo-Blowers for Iron and Steel Plants), M. Schattschneider. Stahl und Eisen, vol. 51, no. 45, Nov. 5, 1931, pp. 1361–1370, 18 figs. Principles of design and factors to be considered; application of blowers; discharge device and diffusor regulation; examples of actual designs.

MAXIMUM OUTPUT. Die Grenzleistung von Turbogeblaesen (Maximum Output of Turbo-Blowers), R. Landsberg. V.D.I. Zeit., vol. 75, no. 45, Nov. 7, 1931, pp. 1383–1388, 14 figs. Economic explanation of term of maximum output; effect of exhaust losses of turbine, of intake velocity of blower, of rpm; upper limit of output given in intake characteristic, lower limit by width of last blade; application to design of turbo-compressors for refrigeration.

TURBO-GENERATORS

GREAT BRITAIN. 50,000-KW. Turbo-Alternators for Dunston Power Station. Engineering, vol. 132, no. 3436, Nov. 20, 1931, pp. 638–639, 4 figs., on p. 642. Three turbo-alternators built by C. A. Parsons and Co., to operate with steam at pressure of 600 lb per sq. in. and temperature of 800 F will each give continuous output of 62,500 kva, at 13,500 volts and 50 cycles, running at 1500 rpm; both high- and low-pressure turbines are of pure reaction type.

W

WAGES

BONUS SYSTEMS. Kostensenkung Durch Praemien fuer Betriebsangestellte (Reduction of Costs by Bonus for Production Employees), P. Seim. Werkstattstechnik, vol. 25, no. 15, Aug. 1, 1931, pp. 369–373, 3 figs. Compensation of managers and foremen by impartial bonus system; examples illustrate procedure of calculation.

WAGE-PAYMENT PLANS. Entlohnung und Betriebsueberwachung (Wage Payment and Production Control), K. Freund. Maschinenbau, vol. 10, no. 14, July 16, 1931, pp. 474–477, 4 figs. Effects of production methods, organization, and time study on choice of wage-payment plans; graphical representation of relations.

WELDING

ALLOY STEEL. See *Chromium Molybdenum Steel.*

BOILERS. See *Boilers—Manufacture.*

COSTS. Estimating Welding Costs, J. H. Zink. Heat. and Piping Contractors Nat. Assn.—Off. Bul., vol. 38, no. 11, Nov. 1931, pp. 32–34. Practical review of cost estimating pipe-welding operations.

ELECTRIC. See *Electric Welding, Arc; Electric Welding, Resistance.*

EQUIPMENT. Neuzeitliches Schmelzschweiss- und Schneidbedarf (Modern Fusion Welding and Cutting Equipment), H. Reininger. Maschinenbau, vol. 10, no. 18, Sept. 17, 1931, pp. 581–587, 36 figs. Recent improvements in oxyacetylene- and electric-welding methods, torches and welding machines; design of different types of cutting machines; properties and application of different steels.

PRESSURE VESSELS. See *Pressure Vessels.*

WELDS

TESTING. Ueber Biegeversuche mit Schweissungen (Bending Tests With Welds), O. Mies. Elektroschweissung, vol. 2, no. 9, Sept. 1931, pp. 170–176, 15 figs. Importance of values obtained from tests, i. e., slope of deflection, bending stresses and flexural stretch as criteria in bending tests of welded and non-welded materials: difference between capability for deformation of weld and that of welding materials.

WIND TUNNELS

GREAT BRITAIN. New Wind Tunnels of Royal Aircraft Establishment, R. McK. Wood. Engineering, vol. 132, no. 3433, Oct. 1931, pp. 563–564, 10 figs. partly on supp. plates. Aerodynamic principles of design of wind tunnels; review of developments; types developed by National Physical Laboratory; large wind tunnel which it is proposed to erect at Farnborough.